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CHARLES SCHUCHERT
1858–1942

CHARLES SCHUCHERT, first-elected president of the Paleontological Society, died in New Haven, Connecticut, November 20, 1942. To his memory this number of the JOURNAL OF PALEONTOLOGY is dedicated in affectionate esteem.

He was born in Cincinnati, Ohio, July 3, 1858, and grew up in the presence of those fossiliferous hills that have nurtured so many American paleontologists. When, at the age of eleven, he chanced to visit the home of a local collector and, for the first time, saw a cabinet of Cincinnati fossils, a spark of enthusiasm was kindled that lighted the rest of his years. Wide-eyed with enchantment, he wanted to know where and how such treasures could be found—and within the hour was off to the hills hunting fossils. This was really the beginning of his amazing scientific career.

He left grammar school after the sixth grade, spent a year trying in vain to learn bookkeeping, and then went to work in his father's furniture factory; but week ends and holidays and weeks of vacation were devoted to hunting fossils. This hobby brought him the acquaintance of other young collectors among whom was E. O. Ulrich who, with three years of college training, had become curator of the collections of the Cincinnati Society of Natural History and was beginning his epoch-making studies on fossil bryozoans. Soon Ulrich and Schuchert were fast friends, drawn together by a common interest in fossils. Ulrich had pre-empted the bryozoans for his study, and Schuchert devoted himself to the brachiopods, trading the rest of his collections to others in order to increase his growing cabinet of fossil Brachiopoda. Thus, while still engaged in the furniture business, he had built up a private collection of brachiopods second to none in the Middle West—a collection that soon became an *open sesame* to a scientific career in which he was destined to attain great distinction and many honors.

He had no scientific training and had never attended a course in geology or paleontology when, at the age of 26, he decided to abandon the furniture business and accept a job as assistant to Ulrich in the preparation of volume VIII of the reports of the Geological Survey of Illinois. But education is not limited to ivied towers; and Schuchert now began to spend his evenings, far into the night, eagerly reading and studying. At first his attention was devoted largely to brachiopod literature, but soon his interests had broadened to other fields of paleontology, stratigraphy, and historical geology, and in later years the extent and range of his reading was phenomenal. He had been with Ulrich scarcely three years when the fame of his brachiopod collection reached the ears of James Hall and, in this way, Schuchert was brought to Albany as Hall's assistant. Later, he was assistant in turn to Winchell, Beecher, and Walcott, finally becoming Assistant Curator of Invertebrate Paleontology in the United States

National Museum in 1894. Ten years at this great scientific center provided a stimulating environment for his further growth and self-education, gave him wide experience both in the laboratory and in the field, and enabled him to travel extensively both here and abroad. During these years he published his *Synopsis of American fossil Brachiopoda* and wrote the chapter on the *Brachiopoda* for the now famous Zittel-Eastman *Textbook of Paleontology*.

In 1904 he was called to Yale to succeed the late Charles E. Beecher as Professor of Paleontology and Historical Geology and Curator of the Geological Collections in Peabody Museum of Natural History. There he became a great teacher and a busy administrator, while his field of interest and research broadened to include many phases of geology, notably stratigraphy and paleogeography; but with all these diversions he never lessened his interest in paleontology or lost his preeminence in the study of fossil brachiopods. Out of 234 titles in his bibliography, 30 are devoted to paleontology, and four of these are notable volumes, three on the Brachiopoda and one on Paleozoic Stelleroidea.

It is not surprising, therefore, that he was one of the leading spirits in the founding of the Paleontological Society. The need of such an organization was discussed before the section of vertebrate paleontologists at the New Haven meeting of the Geological Society of America in 1907, and as a sequel Schuchert invited seven others to join him as a committee to consider ways and means. This group included John M. Clarke, F. B. Loomis, W. J. Sinclair, T. W. Stanton, E. O. Ulrich, C. D. Walcott, David White, and S. W. Williston. During the year they circularized the paleontologists of the country to get advice about various details of organization, and then drew up a proposed constitution and by-laws and issued a call for an organization meeting to be held in connection with the annual meeting of the Geological Society at Baltimore in December 1908. Schuchert presided at this convocation and reviewed the deliberations of the organization committee. An executive committee was then elected by vote of those present, with power to act in organizing the society and choosing officers for the year 1909. This committee consisted of Charles Schuchert, F. B. Loomis, Henry Fairfield Osborn, T. W. Stanton, David White, and Samuel W. Williston. It met in New York in February 1909, adopted a constitution and by-laws, and selected officers for the rest of the year with John M. Clarke as president. The first annual meeting of the Society was held at Harvard in connection with the meetings of the Geological Society of America in December 1909, and at that time Schuchert was elected president and E. O. Ulrich first vice-president.

From the start one of the chief objectives of the Society was to establish a journal for the publication of paleontological research. As a strong supporter of this ideal, Professor Schuchert made repeated efforts to enlist the aid of benefactors who would endow such a publication, and on more than one occasion offered to contribute generously to such a fund if others would join him. His efforts appeared about to bear fruit when in 1930 he was invited to confer with Dr. R. A. F. Penrose and to advise him how best to provide for the use of his estate in the interests of science. Dr. Penrose's unexpected and lamented death intervened before any of the plans then discussed had matured, but in a sense their spirit is now fulfilled in the happy arrangement whereby the JOURNAL OF PALEONTOLOGY is heavily supported by grants from the R. A. F. Penrose Fund of the Geological Society of America.

Professor Schuchert was a member of numerous learned societies and the recipient of many honors. One of the tributes that pleased him most was a portrait in oil presented by his former students to Yale University, where it now hangs in Peabody Museum beside that of his distinguished predecessor, O. C. Marsh. This portrait, reproduced herewith, shows him at his desk at the ripe age of eighty years. To the end of his long life he retained a youthful eagerness and enthusiasm that was truly remarkable. In his death American paleontology has lost a distinguished leader, and many who knew him best have lost a generous and inspiring friend.

CARL O. DUNBAR

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REVISION OF THREE EARLY UPPER CAMBRIAN TRILOBITE GENERA

GILBERT O. RAASCH
Milwaukee Public Museum, Milwaukee, Wis.
AND
CHRISTINA LOCHMAN
Mount Holyoke College, South Hadley, Mass.

ABSTRACT—Recent progress in the study of the earlier Upper Cambrian faunas (*Cedaria*, *Crepicephalus*, and *Aphelaspis*) has resulted in the description and elucidation of the majority of the genera and many of the species.Only three genera remain at present inadequately known or poorly defined—*Uncaspis* Kobayashi, 1935; *Komaspidella* Kobayashi, 1938; and "*Amphion?*" *matutina* Hall. The first two are here completely and correctly defined for the first time, and the latter is recognized as the type of a new genus *Hallaspis*. In addition, two old species are named and revised and a third is here figured for the first time.

THE MORE active study of early Upper Cambrian faunas of the United States during the past decade has led to the description of large numbers of new trilobite genera and species. At present the authors know of only three important and widespread genera of these faunas whose characterizations remain obscure or incomplete, though within recent years two of these genera have been recognized as distinct from the groups to which they had been previously allied. The three genera are *Uncaspis* Kobayashi, 1935, *Komaspidella* Kobayashi, 1938 and *Hallaspis* Raasch and Lochman, n. gen. (genotype *Amphion? matutina* Hall). Recent work in the Cordilleran region by Lochman has indicated that all three genera, though never markedly abundant in individual numbers except very locally, are much more widespread in their geographic range than was previously known. Consequently the correct definition and the clarification of all their generic characters are imperative.

Genus UNCASPIS Kobayashi, 1935, emended

Uncaspis KOBAYASHI, *1935*, Imp. Univ. Tokyo, Jour. Fac. Sci., sec. 2, vol. 4, pt. 2, p. 279.
Uncaspis, RESSER, *1938*, Geol. Soc. America Special Papers 15, p. 105.

Original description.—The general form except for the short spines on the pygidium is similar to that of the Asaphiscidae (ex. *Blainia*). The glabella is long, elevated, rounded in front, and marked by the three pairs of furrows; pygidium large and provided with a conical axis pointed backward and relatively wide border from which a pair of posterior spines is produced.

Emended description.—A relatively small trilobite. Dorsal shield highly convex and steeply paraboloid in transverse section.

Cranidium defined by a nearly or completely intramarginal facial suture; from near the median-anterior point, it runs backward in a highly oblique course across the marginal border; near the inner edge of latter, it turns in a right angle to run obliquely inward in a straight line nearly to dorsal furrow a short distance back of anterior end of glabella; after paralleling dorsal furrow a short distance, it swings gently outward and then inward to define the long, narrow, anteriorly placed palpebral lobes, behind which it again runs backward parallel to and extremely close to the dorsal furrow; after a very short distance, it turns a right angle, and begins an outward course which is at first normal to the longitudinal axis and then gradually rounds into an increasing curve; finally cutting the posterior margin at considerably more than 90° at a point near the genal angles.

Cranidium with a convex, conical, long glabella; glabellar furrows either obsolete or very faint; dorsal furrow shallow but usually distinct; frontal border triangular; frontal limb of varying widths, nearly flat; transverse furrow shallow, broad or narrow; fixed cheeks extremely narrow, virtually nonexistent in the midportion except for the long, narrow palpebral lobes; posterolateral limbs broad, moderately long, with a well-defined intramarginal furrow; a rather shallow occipital furrow defining a broad

flat occipital ring; the furrow is carried forward where it joins the dorsal furrow to lie farther forward on the axis than on the pleura; a slender spine arising from the occipital rim at the postaxial point may be present. Free cheeks with regularly curving distal margins and long genal spines; characterized by the extremely short posterior margin due to the close approach of the facial suture to the genal angle and by the conspicuously convex, roughly bean-shaped eyes (of holochroal structure), accommodated by the very steep drop of the cephalic pleura.

Articulated thorax not known, and the number of segments cannot be inferred; individual segments show that the thorax was about equally divided into three highly convex lobes; the segmental overlap, as indicated by the segmental furrows, was strong over distal portion of the pleura and median portion of the axis but diminished to very weak in between; lateral extremities produced into short but acute posteriorly directed spines; at least one of the segments bears a very long median spine, several bear shorter spines, and some are spineless.

Pygidium narrow, convex, roughly pentangular, with a pair of rather closely spaced posterior spines; axial lobe of medium width, convex, tapered posteriorly, of varying lengths; posterior termination of axis distinct and acute; dorsal furrow prominent; pleural lobes less convex, same width or narrower than axial; a well-defined marginal border, which extends posteriorly into the two short posteriorly directed spines.

Outer surface of test smooth or very finely granulated.

Genotype.—*Uncaspis unca* (Walcott).

Remarks.—In 1916 Walcott (1916, p. 217) described the species *Crepicephalus unca* based upon several fragmentary cranidia, two pygidia and a free cheek from sandstone of the Eau Claire formation of Wisconsin. This particular material has subsequently presented considerable nomenclatural difficulties for several reasons. In the first place, none of the specimens belong to the genus *Crepicephalus;* and secondly, subsequent faunal studies by Raasch in Wisconsin soon revealed that the two pygidia (on which the species characterization is chiefly based) are not congeneric with the cranidia with which Walcott had associated them when he described the species.

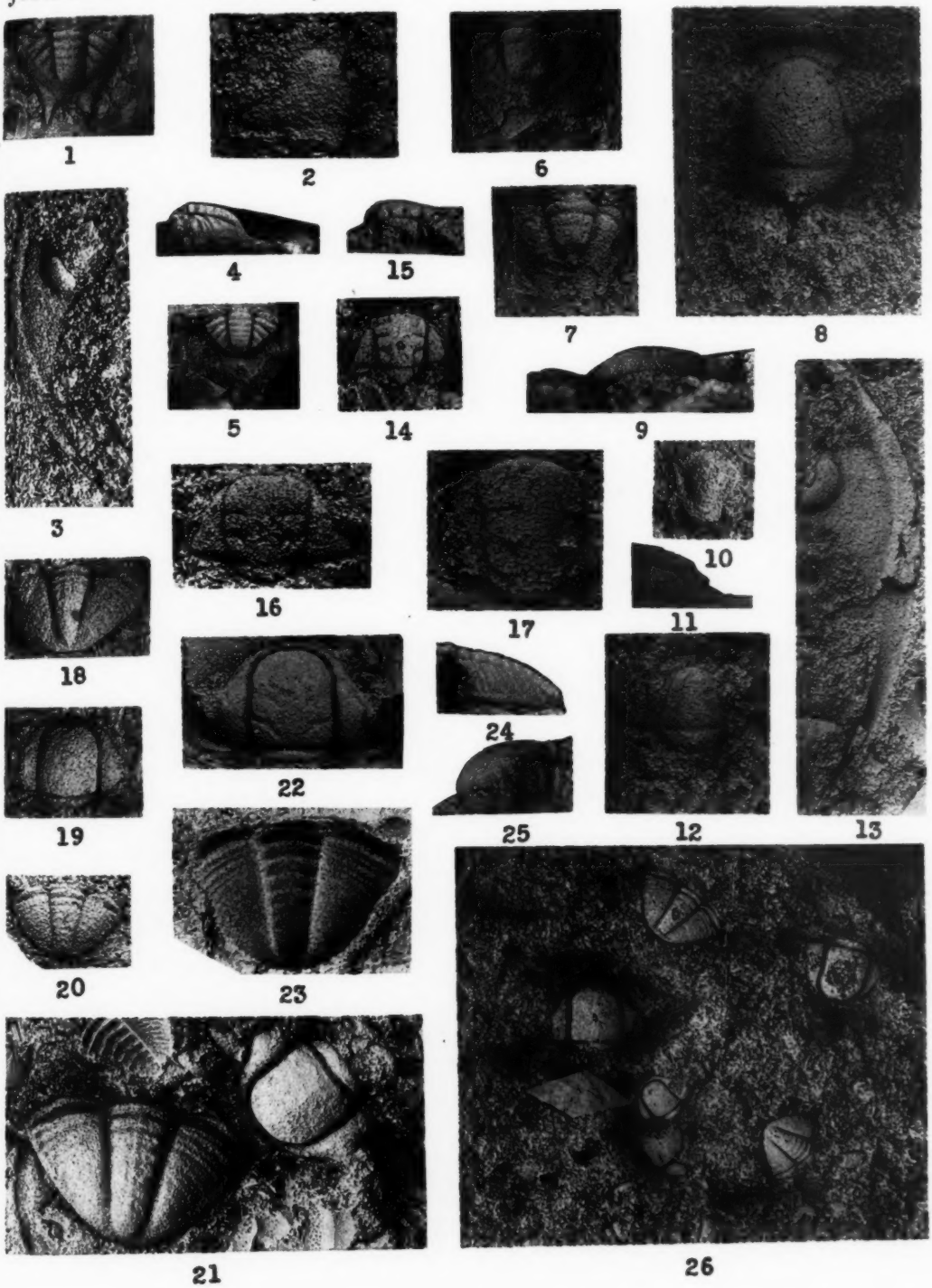
EXPLANATION OF PLATE 34

FIGS. *1–5*—*Uncaspis unca* (Walcott). *1, 4,* Lectoholotype, pygidium, dorsal and side views, U.S.N.M. 61712, ×1; *5,* Paratype, dorsal view of smaller incomplete pygidium, U.S.N.M. 61713, ×1, Willow River, near Hudson, Wis.; *2,* Plesiotype, dorsal view of a small incomplete cranidium, M.P.M. 25013, ×5; *3,* plesiotype, an associated free cheek, M.P.M. 25014, ×5, both from quarry ⅛ mile northeast of brewery, Arcadia, Trempealeau County, Wis. (p. 223)

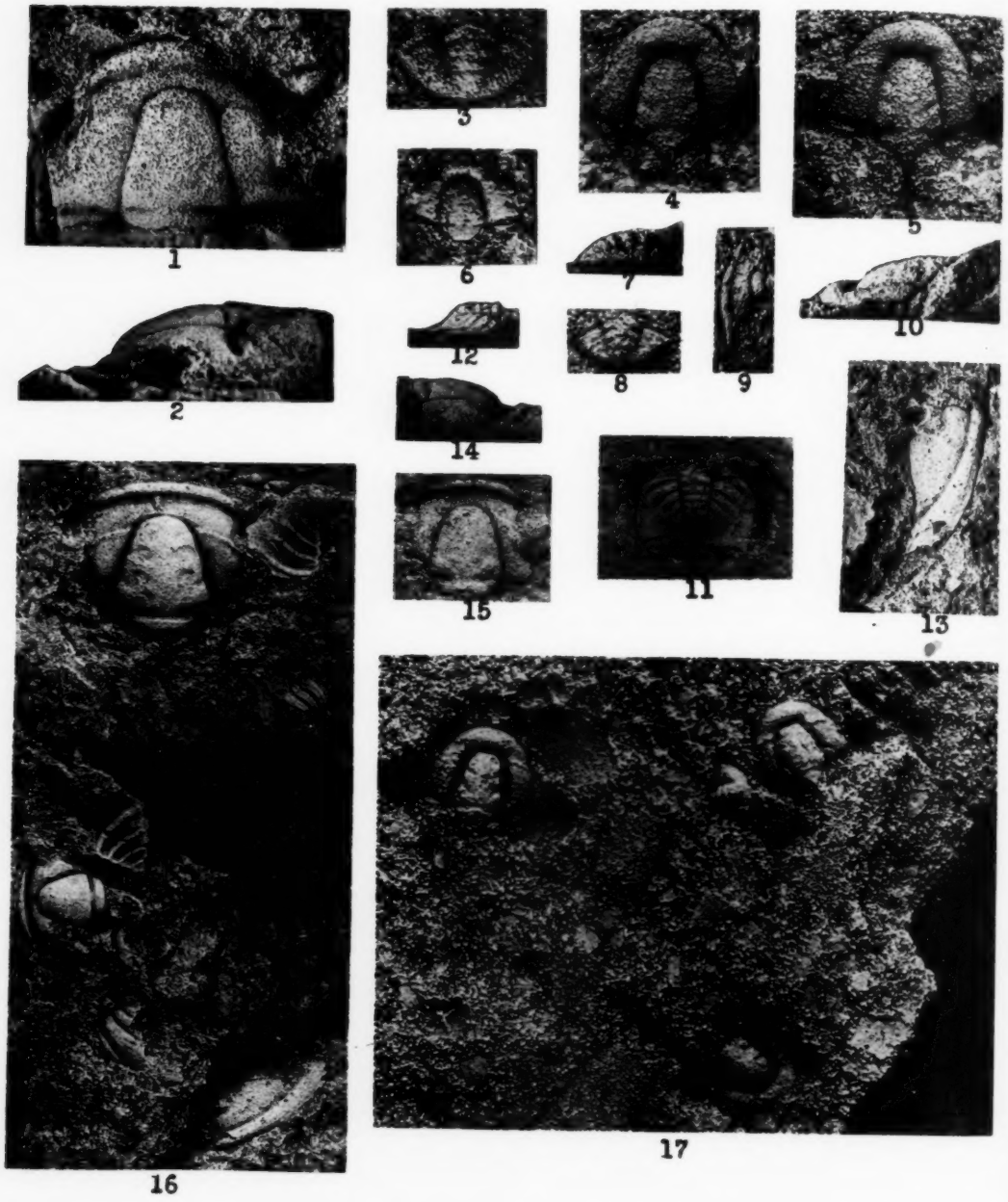
6–13—*Uncaspis limbata* Raasch, n. sp. *8, 9,* Holotype, dorsal and side views of medium-sized cranidium, M.P.M. 25004; *12,* paratype, dorsal view of smaller cranidium showing posterolateral limb, M.P.M. 25006; *6,* paratype, dorsal view of large pygidium showing outer surface, M.P.M. 25005; *7, 11,* paratype, dorsal and side views of smaller pygidium showing position of posterior spines, M.P.M. 25011; *10,* paratype, an associated hypostome, M.P.M. 25010; *13,* paratype, an associated free cheek, M.P.M. 25007, all ×3, quarry at bridgehead, Blair, Wis. (p. 224)

14–17—*Hallaspis matutina* (Hall). *17,* Holotype, dorsal view of the incomplete specimen used by Hall, A.M.N.H. 349, ×5, near Trempealeau, Wis.; *14, 15,* Plesiotype, dorsal and side views of cranidium figured by Walcott U.S.N.M. 61592, ×3.5; *16,* plesiotype, a large complete cranidium, U.S.N.M. 108,482, ×5, both from Dresbach, Winona County, Minn. (p. 230)

18–26—*Komaspidella thea* (Walcott). *26* Holotype dorsal view of type cranidium on slab with other cranidia and pygidia on which Walcott based description but which were never figured U.S.N.M. 23864, ×2, exact locality not known, probably Mt. Washington, Eau Claire, Eau Claire County, Wis. *22, 25,* Plesiotype, dorsal and side views of a complete and well-preserved cranidium, M.P.M. 25045; *21, 24,* plesiotype, dorsal and side views of a large, well-preserved pygidium, M.P.M. 25044; *18,* plesiotype, dorsal view of medium-sized pygidium, M.P.M. 25046; ×3, quarry in southwest corner of Independence, Trempealeau County, Wis.; *19, 20, 23,* dorsal views of small cranidium, small pygidium and mold of large pygidium all on one slab, M.P.M. 25047, all ×3, quarry on Mt. Washington, Eau Claire, Eau Claire County, Wis. (p. 227)



Raasch and Lochman, Cambrian Trilobites



Raasch and Lochman, Cambrian Trilobites

The detailed work in Wisconsin, augmented by the recent studies of Lochman in the Black Hills and Montana, has shown conclusively that a very different type of cranidium (described above) is the correct form to be associated with the pygidia referred to *Crepicephalus unca* Walcott, and that the cranidia placed in this species by Walcott actually belong to the genus *Modocia* (Walcott, 1925, p. 105). However, neither Kobayashi in 1935, when he proposed the genus *Uncaspis* based upon this species, nor Resser in 1938, when he assigned several new species to this genus, were aware of the incorrect association of these cranidia and pygidia.

In the *Crepicephalus* beds of the upper Mississippi Valley the most conclusive evidence as to the correct association of cranidium and pygidium of *Uncaspis* is obtained from a second species, *Uncaspis limbata* Raasch, n. sp., which occurs in faunule I of the *Crepicephalus* zone. This species is now represented by hundreds of specimens from numerous localities and by all parts of the dorsal shield. All these parts are readily distinguishable from similar parts of the three other abundant small associates of this faunule, *Dresbachia*, *Weeksina* and *Komaspidella*.

Only a limited number of specimens of *Uncaspis unca* (Walcott) have been obtained since 1916. This species occurs in the higher faunule III of the *Crepicephalus* zone in Wisconsin, and although the associates of this species are quite different, the same general type of cranidium and free cheek occur with the typical pygidium.

The emendation of the genus has accordingly been based on a generalization of the characters displayed by the two upper Mississippi Valley species and as thus defined it readily accommodates a number of described and undescribed species from other parts of the United States.

Types.—When Walcott described *Crepicephalus unca*, all the specimens used, U.S.N.M. 61709–61713, were considered cotypes. In 1935, being unaware of the error in association of cranidium and pygidium, Kobayashi did not choose a lectotype for the species when he established *Uncaspis*. The emending of the genus has raised the technicality of whether the specific name should belong to the cranidium or the pygidium. The authors believe that the logical choice of a lectotype for *Uncaspis unca* (Walcott) is the pygidium and have acted accordingly. They find that it carries the fundamental concept of the genus because (1) in the generic description Kobayashi clearly puts the emphasis on the character of the pygidium with the short spines; (2) in Walcott's original description of the species the pygidium is described first and again greater emphasis is placed upon its structure than on that of the cranidium; and (3) this greater emphasis has been continued by Resser, who chose pygidia rather than cranidia for the holotypes of his species.

UNCASPIS UNCA (Walcott)
Plate 34, figures 1–5

Crepicephalus unca WALCOTT, *1916*, Smithsonian Misc. Coll., vol. 64, no. 3, p. 217, pl. 35, figs. 1, 1a–e.

EXPLANATION OF PLATE 35

FIGS. *1–2*—*Modocia walcotti* Lochman, n. sp. Holotype, dorsal and side views of cranidium associated by Walcott with pygidia of *Uncaspis unca* (Walcott), U.S.N.M. 61709, ×2, Willow River, near Hudson, Wis. (p. 233)

3–10, 17—*Terranovella dorsalis* (Hall). *5, 10*, Neoholotype, dorsal and side views of a complete cranidium, M.P.M. 25053; *4, 6*, paratypes, dorsal views of two smaller cranidia, M.P.M. 25057, M.P.M. 25056; *3, 7*, paratype, dorsal and side views of large, complete pygidium, M.P.M. 25059; *8*, paratype, dorsal view of smaller pygidium, M.P.M. 25060; *9*, paratype, an associated free cheek, M.P.M. 25056; *17*, paratypes, slab with associated cranidia and pygidia, M.P.M. 25058, all ×5, quarry ⅛ mile northeast of brewery, Arcadia, Trempealeau County, Wis. (p. 234)

11–16—*Crepicephalus oweni* Raasch, n. sp. *15, 14*, Holotype, dorsal and side views of medium size cranidium, M.P.M. 25050; *11, 12*, paratype, dorsal and side views of a medium-sized, well-preserved pygidium, M.P.M. 25049; *13, 16*, paratypes, dorsal views of cranidia, free cheeks and fragmentary pygidia, all associated on one slab, M.P.M. 25051, all ×1, quarry in southwest corner of Independence, Trempealeau County, Wis. (p. 231)

Uncaspis unca, KOBAYASHI, *1935*, Imp. Univ. Tokyo Jour. Fac. Sci., sec. 2, vol. 4, pt. 2, p. 279.

Original description.—The pygidium of this species is not unlike that of *C. dis* from the House Range of Utah. It differs in having the two posterior spines of the pygidium near together and in their broader base where joining the flattened border.

The associated cranidium is similar in outline to that of *C. dis*, but differs in having proportionally broader fixed cheeks.

The largest pygidium has a length of 12 mm. exclusive of the spines.

Emended description.—Cranidium narrow, elongate, with heavy posterolateral limbs; glabella slightly convex, broadly conical; no glabellar furrows observed; dorsal furrow very shallow, narrow; frontal border narrow, triangular, very slightly upturned, separated by an extremely shallow transverse furrow from the narrow, straight, flat frontal limb; free cheek extremely narrow; palpebral lobe not observed; posterolateral limbs broad, triangular, of medium length, with a narrow, well-defined intramarginal furrow; occipital ring of medium width, flat; occipital spine not observed on plesiotype; occipital furrow narrow, shallow. Free cheek narrow, elongate; eye of medium size, prominent; ocular platform of medium width, nearly flat; marginal border narrow, slightly convex, with a long pointed anterior projection and a slender genal spine; marginal furrow narrow.

Facial suture cutting anterior margin at center, running obliquely out and down, then turning abruptly to run straight in to and curve around palpebral lobes; thence curving out and down and then in to cut posterior margin just within genal angle.

Pygidium subtriangular in outline; axial lobe of medium width, convex, tapering posteriorly, extending three-fourths length of pygidium, crossed by four shallow furrows; pleural lobes slightly narrower than axial, low, marked by four narrow, short furrows; marginal border continuing slope of pleural lobes, narrow anteriorly, increasing in width posteriorly and extending into two short posteriorly directed pointed spines, spaced on a line with the anterior sides of axial lobe.

Outer and inner surface of test not known.

Remarks.—Although this species is the genotype of *Uncaspis*, it is unfortunately known from only a few specimens. *Uncaspis limbata* Raasch, n. sp., is the much more common form in the *Crepicephalus* zone of Wisconsin. Since 1916 only a few specimens have been obtained either from the Hudson locality or from other localities. The description of the cranidium and free cheek are based upon the best material available at the Milwaukee Public Museum, but these are only indifferently preserved.

Occurrence.—Upper Cambrian, Eau Claire member of the Dresbach formation, *Crepicephalus* zone (subzone III, *C. iowensis* faunule). WISCONSIN: locality U.S.N.M. 79, Hudson; U.S.N.M. 79e, Willow River Falls, near Hudson, St. Croix County; U.S.N.M. 79c, Willow River, near Hudson; quarry one-eighth mile northeast of brewery at Arcadia, Trempealeau County; La Crosse River at Neshonoc, La Crosse County.

Types.—Lectotype, a pygidium, U.S.N.M. 61712, locality U.S.N.M. 79c; paratype, a pygidium, U.S.N.M. 61713, locality U.S.N.M. 79c; plesiotype, a free cheek, M.P.M. 25014; plesiotypes from the plesiotype, a cranidium, M.P.M. 25013, both plesiotypes from the quarry ½ miles northeast of the brewery at Arcadia, Trempealeau County, Wis.

UNCASPIS LIMBATA Raasch, n. sp.
Plate 34, figures 6–13

Cranidium narrow, elongate in outline; glabella broadly conical, moderately convex; no glabellar furrows observed; dorsal furrow narrow, shallow; frontal border triangular in shape, of medium width at center, slightly curved in profile and upturned at an angle of approximately 90° from direction of frontal limb; transverse furrow broad but shallow; frontal limb of medium width, flat, downsloping; fixed cheeks nonexistent; palpebral lobes narrow, flat, arcuate, lying anterior to transverse median line of glabella; posterolateral limb wide, of medium length with a well-defined intramarginal furrow; occipital furrow well-defined but shallow; occipital ring of medium width, flat, triangular in shape, extending into a short slender occipital spine. Free cheek narrow, elongate, with prominent, medium-sized eye at inner angle; ocular platform of medium width, flat; marginal furrow narrow,

shallow; marginal border narrow, slightly convex, extended anteriorly into a long pointed projection and posteriorly into a long, slender genal spine.

Facial suture cutting anterior margin on median line, curving out and back to transverse furrow, then turning abruptly and running diagonally straight in to touch dorsal furrow; curving around palpebral lobes; thence curving outward, first slightly forward, then down and in to cut posterior margin just within genal angle.

Hypostome rectangular in outline, anterior margin apparently curved; lappets short, triangular; anterior lobe a low symmetrical oval bordered by a very narrow shallow furrow; posterior lobe a convex semicircular expansion bordered posteriorly and laterally by a narrow, shallow furrow; a well-defined macula at each posterolateral corner; a narrow, convex border along lateral and posterior sides, which shows definite undulation along posterior edge.

Thorax not known.

Pygidium broadly pentagonal in outline; axial lobe moderately convex, broad, short, only slightly more than one-half (approx. $\frac{2}{3}$) length of pygidium, tapering only slightly but extended beyond axis in a low pointed median elevation over border; marked by three narrow shallow segments and two prominent lateral nodes at posterior corners; pleural lobes approximately one-half width of axial, slightly convex, sharply downsloping, marked by two or three short, shallow faint furrows; marginal border nearly flat, continuing slope of pleural lobes, of medium width anteriorly, increasing in width somewhat posteriorly, continued posteriorly into the short, flat pointed spines, which diverge slightly so that the tips are beyond the sides of the axial lobe.

Outer and inner surfaces of test not known.

Remarks.—In recent collections from Blair, Wis., this species is very abundantly represented by all parts of the carapace, and these, supplemented by Lochman's material from the Deadwood formation of the Black Hills, have proved the correct association of the cranidium, free cheek and pygidium for the genus *Uncaspis*. This discovery has enabled us to prepare the above complete description for this genus.

Uncaspis limbata Raasch, n. sp., differs from *U. unca* (Walcott) in the proportionally larger frontal limb and the upturned frontal border of the cranidium and in the wider marginal border, less well defined segmentation, and the somewhat divergent posterior spines of the pygidium. The pygidium cannot with certainty be separated from *Uncaspis angustata* Resser from the Tennessee Nolichucky, but as that species is based on a single distorted and poorly preserved pygidium the authors hesitate to identify the Wisconsin forms with that species.

Occurrence.—Upper Cambrian, Eau Claire member of the Dresbach formation, *Crepicephalus* zone (in the upper part of subzone I, *C. oweni* faunule, and the lower part of subzone II, *C. rectus* faunule). WISCONSIN: 1 mile southeast of Mondovi, Buffalo County; Albertville, Chippewa County; 12 to 14 feet above base of *Crepicephalus* zone in quarry 1 mile north of Colfax; Rock Falls, Dunn County; quarry on Mt. Washington, Shawton, Eau Claire, Eau Claire County; Strum; quarry in southwest corner of Independence; shale pit $2\frac{1}{2}$ miles southwest of Independence; shale pit $1\frac{1}{2}$ miles west of Independence; 13 feet above base of *Crepicephalus* zone in the quarry at bridgehead at Blair; shale pit on State Highway 95, 2 miles east of Blair; shale pit on State Highway 93, north edge of Arcadia, Trempealeau County.

Types.—Holotype, a cranidium, M.P.M. 25004: Paratypes: a cranidium, M.P.M. 25006; a cranidium and a pygidium, M.P.M. 25011; a pygidium, M.P.M. 25005; a free cheek, M.P.M. 25007; a free cheek, M.P.M. 25012; a hypostome, M.P.M. 25010; possible thoracic segments, M.P.M. 25009, M.P.M. 25008. All from 13 feet above base of *Crepicephalus* zone at quarry at bridgehead at Blair, Wis.

SPECIES OF UNCASPIS

In the course of this study, all the species referred to *Uncaspis* to date have been examined, and it was found that some are not correctly assigned to this genus. The valid species are *Uncaspis unca* (Walcott), *Uncaspis limbata* Raasch, n. sp., *Uncaspis angustata* Resser. A possibly valid species is *Uncaspis micans* Resser, but the cranidium

must be found before the positive generic position can be determined.

Species not correctly assigned are *Uncaspis nitida* Resser (both the cranidium and pygidium belong to *Crepicephalus*) and *Uncaspis tennesseensis* Resser (the cranidium belongs to *Coosella;* the holotype pygidium is either an extremely aberrant species of *Uncaspis* or else represents an undescribed genus, but no definite statement can be made until more and complete specimens of the pygidium and specimens of the associated cranidium have been obtained).

Genus KOMASPIDELLA Kobayashi, 1938

Komaspidella KOBAYASHI, *1938*, Japanese Jour. Geology and Geography, vol. 15, nos. 3, 4, pp. 174–175.

Original description.—Glabella subsquare or subovate and provided with three pairs of short glabellar furrows; eyes relatively small and located at the midlength of the cranidium; no raised frontal rim.

Supplementary description.—Cranidium short and broad; glabella low, proportionally wide, with parallel sides and rounded front; two or three short arcuate glabellar furrows; dorsal furrow deep and prominent; no frontal border or transverse furrow; frontal limb a narrow vertical band in front of dorsal furrow; fixed cheeks narrow; medium-sized palpebral lobes situated on a line posterior to the center of glabella; posterolateral limbs narrow, of medium length, with a broad, shallow intramarginal furrow; occipital ring narrow; occipital furrow deep. Free cheek not known.

Facial suture cutting anterior margin just in front of anterolateral corners of dorsal furrow, running diagonally back to and curving around palpebral lobes; then curving back and around to cut posterior margin just within genal angle.

Thorax not known.

Pygidium subtriangular in outline, regularly convex in profile; axial lobe low, long, with eight or nine narrow segments; pleural lobes wider than axial, regularly convex, marked by seven or more segments; a very narrow marginal border.

Outer surface of test probably granulated.

Genotype.—*Komaspidella thea* (Walcott).

Remarks.—*Komaspidella* was erected by Kobayashi for a small early Upper Cambrian trilobite genus represented at present by two described species. The genotype, *K. thea* (Walcott), was described in 1890 by Walcott as *Agraulos? thea*, based on only a few specimens. Even at that time Walcott was in doubt concerning the generic relationship, and subsequently he reassigned the form to a new Chinese genus, *Pagodia* (Walcott, 1914, p. 358), in a faunal list of the Eau Claire formation from Mount Washington, Eau Claire, Wis. The species is one of the most common members of the *Crepicephalus* fauna at this locality, and later Walcott obtained many more specimens. In 1916 he figured (1916, no. 3, pl. 37) a typical slab of the fauna of *Crepicephalus* zone I on which a number of cranidia and pygidia of *Pagodia thea* (Walcott) are marked.

A comparison of this species with the cranidia and pygidia of *Pagodia lotos* Walcott (1905, pp. 63, 64; 1913, pp. 160, 163), genotype of *Pagodia*, from the Upper Cambrian, Ch'au-mi-tién limestone, 1 mile west of Tsi-nan, Shantung, China, reveals the fact that there is no similarity between the pygidia and very little between the cranidia, the subsquarish glabella and narrow frontal border of *Pagodia* apparently being the features which attracted Walcott's attention. This obvious dissimilarity led to a dissatisfaction among Cambrian students as to the generic designation of the species *P. thea*, and numerous suggestions were made but no action taken. Actually the species represents a distinct genus, and its assignment to the new genus *Komaspidella* by Kobayashi in 1938 finally and correctly settled the matter of its generic name.

At present there is only one other published species, the very closely allied *K. seelyi* (Walcott) from the Potsdam sandstone of New York. This species was described by Walcott in 1912 (p. 269) as *Pagodia seelyi*. The "somewhat similar forms from the Pogonip limestone of Nevada" mentioned by Walcott in the description of the above species were examined and was found to be a cranidium that is clearly referable to the much later genus *Leiostegium*. The species *Arionellus levis* Walcott, mentioned by Kobayashi (1938, p. 75) as prob-

ably belonging to this genus, was also examined by us and was found not to be congeneric with *K. thea* (Walcott). We do, however, agree with Kobayashi that it was not correctly assigned by Resser when he placed it in *Plethopeltis*.

Resser (1942) has placed *Komaspidella thea* (Walcott) and *K. seelyi* (Walcott) in synonymy with *Kingstonia*, basing this assignment upon the argument that

> the Wisconsin specimens are internal casts and consequently that they do not have the true aspect of their respective genera, for this mode of preservation always exaggerates the furrows. (Resser, 1942)

We cannot accept this assignment and recognize *Komaspidella* as a valid genus, not necessarily even closely related to *Kingstonia*. Though Resser's general statement quoted above that the furrows are stronger (or more deeply impressed) on internal casts than on external molds is quite correct and can be verified by examination of numerous limestone internal casts (peeled specimens) of *Kingstonia*, nevertheless it is also quite clear from such an examination that the general convexity and the proportions of parts to the whole both in the cranidium and the pygidium are unaffected by the type of preservation. It is in such features that *Komaspidella* differs markedly enough from *Kingstonia* to be considered a distinct genus.

Below have been tabulated the differences between *Kingstonia* and *Komaspidella*. (1) The cranidium of *Kingstonia* is regularly convex (a semicircular profile) with the fixed cheeks continuing the downslope of the sides of the glabella; the cranidium of *Komaspidella* has a horizontal profile, with slightly convex glabella and nearly flat horizontal fixed cheeks.

(2) The glabella of *Kingstonia* has moderately converging sides, the greatest convexity in the posterior half, and slopes regularly downward anteriorly continuing into the downsloping frontal limb without a break in slope; the glabella of *Komaspidella* has straight parallel sides, a slight convexity in center and posterior, with an abrupt change in slope just anterior to palpebral lobes as it curves downward sharply, and is separated from the narrow rimlike preglabellar area not only by the prominent dorsal furrow but also by a marked change in slope, since the posterior part of this area is flat and horizontal in position.

(3) The palpebral lobes of *Komaspidella* are larger and more prominent in proportion to the fixed cheeks than those of *Kingstonia*.

(4) The pygidium at present associated with *Komaspidella* has a 3:2 proportion of anterior width to midline length, the axial lobe tapers regularly to a narrow rounded terminus, the wider pleural lobes are regularly convex, downsloping from the dorsal furrow to the border, the marginal border is nearly flat along the sides becoming vertical around the posterior; the pygidium of *Kingstonia* has a 3:2 proportion of anterior width to midline length, the axial lobe has subparallel sides, tapering only slightly to a broadly rounded terminus, the pleural lobes are same width as axial and flat (horizontal in position), the marginal border is vertical all around.

KOMASPIDELLA THEA (Walcott)
Plate 34, figures 18–26

Agraulos? thea WALCOTT, *1890*, U. S. Nat. Mus. Proc., vol. 13, p. 277.
Pagodia thea, WALCOTT, *1914*, Smithsonian Misc. Coll., vol. 57, no. 13, p. 358.
Komaspidella thea, KOBAYASHI, *1938*, Japanese Jour. Geology and Geography, vol. 15, no. 3–4, p. 175.
Kingstonia thea, RESSER, *1942*, Smithsonian Misc. Coll., vol. 101, no. 15, p. 26.

Original description.—Glabella convex; sides subparallel; front broadly rounded; surface marked by three pairs of slightly impressed furrows; occipital segment narrow, transverse, clearly defined by the narrow transverse occipital furrow; dorsal furrow deep all about the glabella.

Free cheeks[1] subtumid and merging anteriorly into the narrow, rounded frontal limb; palpebral lobe of medium size and situated a little back of a transverse line crossing the center of the head; posterolateral limbs short and strongly grooved by the marginal furrow; frontal limb very short and rounded into the margin.

The associated pygidium is subtriangular in outline, convex; median lobe narrow, convex, elevated above the general surface of the pygidium; divided by transverse furrows into eight or nine anchylosed segments; both the furrows and the segments are carried out onto the convex lateral lobes.

This species occurs with *Ptychoparia minor* in

[1] A misprint for fixed cheeks. Walcott did not have any free cheeks for this species nor has it yet been possible to associate free cheeks with the cranidia and pygidia.

the lower horizon of the Wisconsin Upper Cambrian section. The characters of the head and pygidium are such that the species is referred provisionally to Agraulos.

Formation and locality.—Upper Cambrian (Potsdam terrane). Osceola Mills, Wis. Collector, Dr. Cooper Curtice.

Nat. Mus. Cat. Invert. Foss., 23864.

Supplementary description.—Of the glabellar furrows, the two posterior pairs are arcuate and fairly well defined; the anterior pair is very faint.

A low, narrow ocular ridge crosses the fixed cheek diagonally from the palpebral lobe to just in front of the beginning of the curvature of the front of the glabella; there is a narrow well-defined palpebral furrow.

Facial suture cutting anterior margin just in front of anterolateral corners of dorsal furrow, running diagonally back and out, then curving into and around palpebral lobes; thence running diagonally out and then curving down to cut posterior margin just within genal angle.

On the pygidium the axial lobe is low, narrow, extending practically full length of pygidium, tapering moderately to posterior, divided into nine poorly defined segments and a small terminal portion, and marked medially by a low ridge; dorsal furrow well defined; pleural lobes nearly twice width of axial, regularly convex, marked by six or seven shallow furrows; a very narrow marginal border, nearly flat anteriorly but gradually becoming vertical posteriorly.

Outer surface of test appears to have been covered by small granules.

Remarks.—It will be noted that though brief Walcott's original description is essentially accurate—more so than Kobayashi's later generic definition, as Walcott noted the correct position for the palpebral lobes.

The entire description and discussion of Walcott has been quoted in order that attention might be called to the locality assignment of the type specimen, given by Walcott as Osceola Mills, Wis. This locality is incorrect, for no beds of the *Crepicephalus* zone are exposed anywhere in the vicinity of Osceola Mills, a locality which is characterized by numerous fossiliferous outcrops of the Trempealeau formation. We consider it very probable that the specimens actually came from the *Crepicephalus* zone I on Mount Washington, Shawton, Eau Claire, Wis., an extremely fossiliferous locality and one well known to the early collectors.

Although Walcott described the pygidium, he did not figure it, and the cranidium was figured only by a line drawing. Both the holotype cranidium and the pygidium are here figured adequately for the first time. A number of well-preserved plesiotypes have also been figured.

Occurrence.—Upper Cambrian, Eau Claire member of the Dresbach formation, *Crepicephalus* zone (subzone I, *C. oweni* faunule—characteristic and common). WISCONSIN: Beds 3–5 in quarry in southwest corner of Independence; in lower 12 feet of zone in shale pit on State Highway 93 at bridgehead 2½ miles southwest of Independence; near base of exposure in shale pit on State Highway 93 one mile northeast of limits of Arcadia; bed 1 in shale pit on State Highway 93, north edge of Arcadia; 12 feet above top of *Cedaria* zone, in shale pit on State Highway 95, 2 miles east of Blair; 13 feet above top of *Cedaria* zone, in shale pit at dam at Blair; immediately overlying *Cedaria* zone in shale pit at Strum; Eleva, all in Trempealeau County. Bed 8, shale pit on Mt. Washington, Shawton, Eau Claire; 4 miles west of Eau Claire; on State Highway 37, 1¼ miles south of Mt. Hope Corners; all in Eau Claire County. Exposure at Hunter's Bridge on Black River, La Crosse County Rock Falls; bed 7 in quarry 1 mile north of Colfax, both in Dunn County. Beds 3 and 4, ¼ to ½ mile west of railway station at Albertsville, Chippewa County.

Crepicephalus zone (subzone II, *C. rectus* faunule—rare). Quarry on Mt. Washington, Shawton, Eau Claire, Eau Claire County, Wis.

Types.—Holotype, a cranidium, U.S.-N.M. 23864; paratype, a pygidium, U.S.-N.M. 23864a. Exact locality not known, probably Mt. Washington, Shawton, Eau Claire, Eau Claire County, Wis.

Plesiotypes: Cranidia and pygidia on slab, U.S.N.M. 61737, Rock Falls, Dunn County, Wis. Cranidia and pygidia, M.P.M. 25044 and a cranidium, M.P.M. 25045, from division 3; pygidia, M.P.M. 25046, from division 5; quarry in southwest corner of Independence, Trempealeau County, Wis.

Plesiotypes, cranidia and pygidia, M.P.M. 25047, quarry on Mt. Washington, Eau Claire, Eau Claire County, Wis.

Genus HALLASPIS Raasch and Lochman, n. gen.

Cranidium short and broad; a broad glabella with sides diverging slightly to a broadly rounded front; two pairs of short glabellar furrows; dorsal furrow only along sides of glabella; no frontal limb or transverse furrow; frontal border a narrow rim; fixed cheeks one-half or less the width of glabella; palpebral lobes small, arcuate, situated on line with anterior glabellar furrows; a narrow palpebral furrow; posterolateral limbs short but moderately wide, with well-defined intramarginal furrow; occipital ring flat, with short stout occipital spine. Free cheek not known.

Facial suture cutting anterior margin apparently far out at sides, running short distance straight back to, then curving around palpebral lobes; thence curving down and back to cut posterior margin within genal angle.

Thorax and pygidium not known.

Genotype.—Amphion? matutina Hall.

Remarks.—The genus *Hallaspis* is established for the reception of a small rather uncommon species in the *Cedaria* and *Crepicephalus* faunas of Wisconsin and the Cordilleran region that has been shifted from genus to genus through the years but actually is not congeneric with any described genus. Hall first doubtfully referred it to the genus *Amphion*. Later Walcott (1916, p. 219), though recognizing that the species was not correctly assigned as to genus, hesitated to describe it as a new genus until he had obtained more complete material. Apparently he had available only the holotype, A.M.N.H. 349, which is very fragmentary (pl. 1, fig. 17) and the plesiotype, U.S.N.M. 61592. Although it must be admitted that to date no free cheek nor pygidium has been obtained, nevertheless a number of cranidia are now available from the Wisconsin region and a few from Montana, so that a fairly accurate concept of this portion of the carapace can be obtained, and we feel justified in recognizing the form as a distinct genus.

In 1924 when Raymond established the genus *Acheilus* (1924, pp. 166–167) he assigned *Amphion? matutina* to this genus, of which *Acheilus marcoui* Raymond from the boulders in the Levis conglomerate is the genotype. Although the general glabellar structure of the cranidium of this species is much the same as that of *Hallaspis matutina* (Hall), a detailed comparison of the cranidia breaks down any apparent similarity; in fact, the following table reveals that about the only thing they have in common is the lack of frontal limb and transverse furrow, and the swollen anterior portion of the glabella.

Hallaspis matutina (Hall)	*Acheilus marcoui* Raymond
Glabella broad, sides diverging regularly to broadly rounded front.	Glabella very broad, sides parallel to palpebral lobes, then expanding to form swollen front.
Two pairs of short glabellar furrows, anterior pair straight, posterior pair arcuate.	Two pairs of short, very narrow, nearly obsolete glabellar furrows, anterior pair straight, posterior pair arcuate.
Occipital ring subtriangular with a short occipital spine.	Occipital ring narrow, arcuate; no occipital spine.
Posterolateral limbs short, wide (one-half length of cranidium).	Posterolateral limbs short, narrow (one-third length of cranidium).
Fixed cheeks one-third width of glabella.	Fixed cheeks very narrow, flat (one-eighth or less width of glabella).
Palpebral lobes small, arcuate, situated anterior to transverse median line of glabella.	Palpebral lobes medium-sized, arcuate, situated posterior to transverse median line of glabella.
No frontal limb or transverse furrow.	No frontal limb or transverse furrow.
Frontal border a very narrow, vertical rim under front of glabella.	No frontal border. Facial suture runs right along anterior margin.

Finally in 1936 Resser placed the species in *Stenochilina*, a genus to which it shows very little affinity. A comparison of *Hallaspis matutina* (Hall) and *Stenochilina spinifera* Ulrich (Bridge, 1930, p. 125), the genotype from the Eminence dolomite of Missouri, reveals that the possession of an occipital spine is the only feature which the two cranidia have in common.

Hallaspis matutina (Hall)	*Stenochilina spinifera* Ulrich
Glabella broad, sides diverging regularly to broadly rounded front.	Glabella broad, sides parallel to front of palpebral lobes, then converging to a rounded front.
Two pairs of short glabellar furrows, anterior pair straight, posterior pair arcuate.	Two pairs of glabellar furrows, anterior pair joined medially to form a complete arc, posterior pair laterally arcuate, joined medially by a straight furrow.
Occipital ring subtriangular, with a short occipital spine.	Occipital ring subtriangular, with a short occipital spine.
Posterolateral limbs short, wide (one-half length of cranidium).	Posterolateral limbs extremely short, narrow (one-fourth length of cranidium).
Fixed cheeks one-third width of glabella.	Fixed cheeks one-sixth width of glabella.
Palpebral lobes small, arcuate, situated opposite anterior pair of glabellar furrows.	Palpebral lobes arcuate, parallel sides of glabella, situated on transverse median line of glabella.
No frontal limb or transverse furrow.	Frontal limb a very narrow band around front of glabella, no transverse furrow.
Frontal border a very narrow, vertical rim under front of glabella.	Frontal border lacking.

There is no known genus in the Upper Cambrian trilobite assemblage to which *Hallaspis* appears to be closely related. The closest similarity in the structure and proportions of the cranidium is to be found in *Madarocephalus laetus* Resser. However, this genus does not show the prominent glabellar furrows of *Hallaspis*, and even more important, the position of the palpebral lobes and the course of the facial suture are quite different.

HALLASPIS MATUTINA (Hall)
Plate 34, figures 14–17

Amphion? matutina HALL, *1863*, New York State Cab. Nat. History 16th Ann. Rept., p. 222, pl. 5a, fig. 6: *1867*, Trans. Albany Inst., vol. 5, p. 194.

Amphion? matutina, WALCOTT, *1916*, Smithsonian Misc. Coll., vol. 64, no. 3, p. 219, p. 26, fig. 8.

Acheilus matutina, RAYMOND, *1924*, Rept. Vermont State Geol., p. 167.

Stenochilina matutina, RESSER, *1936*, Smithsonian Misc. Coll., vol. 95, no. 4, p. 27.

Original description.—Glabella gibbous, longer than wide, subovate, rounded and a little wider in front. Occipital ring narrow and straight; occipital furrow narrow. Posterior lobe a little oblique, the furrow deeply impressed and a little expanded at its inner extremity: median lobe with the sides nearly parallel, separated from the anterior lobe by a narrow distinct furrow; anterior lobe broad, the length somewhat less than half the entire length of the glabella, a scarcely defined depression extending obliquely from near the middle of its length to the front.

A part of one of the fixed cheeks remaining is semielliptical, a little wider behind than in front.

The specimen is too imperfect to admit of tracing the facial suture.

Supplementary description.—Cranidium short and broad with a broad, moderately convex glabella with sides diverging slightly anteriorly to a broadly rounded front; two pairs of short, prominent glabellar furrows, anterior pair straight or very slightly curved, posterior pair arcuate; no frontal limb or transverse furrow; frontal border a narrow, vertical rim across front of glabella; anterior margin very slightly curved; dorsal furrow narrow, well defined, only at sides of glabella; fixed cheeks approximately one-third width of glabella, slightly convex; palpebral lobes small, arcuate, situated on line with anterior glabellar furrows; palpebral furrow narrow, well defined; posterolateral limbs short, wide, with a wide intramarginal furrow; occipital furrow narrow, well defined; occipital ring triangular with a short, stout occipital spine. Free cheek not known.

Facial suture apparently cutting anterior margin far out on sides, running straight back a short distance, then curving out

around palpebral lobes; thence curving out and back to cut posterior margin within genal angle.

Thorax and pygidium not known.

Outer and inner surface of test not known.

Remarks.—The more recently obtained specimens of cranidia of this species have enabled the authors to round out the specific description of this portion of the carapace. In one respect their specimens and Walcott's specimen appeared to disagree with the holotype; i.e., far forward on the glabella there was not the slightest trace of the third pair of glabellar furrows that are mentioned by Hall in his description and shown in his figure. An examination of the holotype (pl. 34, fig. 17) showed that this specimen also did not show the furrows, and the only explanation the authors can offer for this discrepancy is that a slight blemish on the left side, front, of the glabella, caused by the removal of one of the sand grains, led Hall into this error.

Occurrence.—Upper Cambrian, Eau Claire member of the Dresbach formation. *Cedaria* zone: Quarry one mile north of Colfax, Dunn County, Wis. *Crepicephalus* zone (subzone I, *C. oweni* faunule): Quarry in southwest corner of Independence, Trempealeau County, Wis. *Crepicephalus* zone (subzone III, *C. iowensis* faunule): Quarry at brewery, Arcadia, Trempealeau County, Wis.; shale pit at Neshonoc, one mile north of West Salem, La Crosse County, Wis.; Dresbach, Winona County, Minn. (U.S.-N.M. locality 86); La Moile, Winona County (ref. Peterson), Minn.

Types.—Holotype, fragmentary cranidium, A.M.N.H. 349—near Trempealeau, Wis.

Plesiotypes. A cranidium, U.S.N.M. 61592, and a cranidium, U.S.N.M. 108,482, from Dresbach, Winona County, Minn.; a cranidium, M.P.M. 25043, from 1 mile north of West Salem, La Crosse County, Wis.

REVISION OF THREE OLD SPECIES

In addition to the three preceding genera that have been emended, there are three old species that may conveniently be redescribed and clarified at this time. One is the species that Owen used in 1852 as the basis for his description of the genus *Crepicephalus* and figured as the example of the genus. It is now named *Crepicephalus oweni* Raasch, n. sp., and described and refigured. Another is the form represented by the cranidia and free cheek erroneously associated by Walcott with the pygidia of *Uncaspis unca* (Walcott), but which actually represent a species of *Modocia*, here named and described as *Modocia walcotti* Lochman, n. sp. The third species was described by Hall in 1863 as *Conocephalites? (Arionellus?) dorsalis* Hall but was not figured. Later the types were apparently lost, and the species was forgotten as it was never reconsidered by Walcott in his various revisions of the faunas of the Eau Claire member. Recently Raasch has obtained many specimens clearly referable to this species, which belongs to the genus *Terranovella* (Lochman, 1938). The species is here redescribed and figured for the first time.

CREPICEPHALUS OWENI Raasch, n. sp.
Plate 35, figures 11–16

Crepicephalus OWEN, *1852*, Report Geol. Survey Wisconsin, Iowa and Minnesota, p. 576, pl. 1A, figs. 10, 18.

Crepicephalus? OWEN, *1852*, idem, p. 576, pl. 1, fig. 8; pl. 1A, fig. 16.

Original generic description.—Some rich Trilobite slabs, occupying the position of the third Trilobite-bed at the Mountain Island section, contain numerous fragments of a Trilobite, a portion of the cephalic shield of which is seen on the medal-ruled slab, fig. 16 of Tab. 1A, on the left corner, as well as by figs. 10 and 18 of the same plate. These, as far as preserved, approach somewhat in form to the genera *Solenosema*, *Micropyge*, and *Endogramma;* but if the caudal shields, fig. 8 of Tab. 1, and fig. 16 of Tab. 1A, correspond, which seems improbable (probable), as they are abundantly disseminated in the same bed, and are mineralized in the same manner into a brown, ferruginous crust, contrasting strongly against the gray gritstone, then this Trilobite of Mountain Island, must constitute a genus distinct from either of these, and for which the name *Crepicephalus* is proposed.

The rather flat slipper-shaped glabella is tapering and slightly acuminated anteriorly, with a faint ridge in the median line; two small and very superficial depressions, and a posterior faint furrow, very partially divide the glabella. The facial sutures run nearly parallel to the margin of the glabella, and join a thickened, cordlike, anterior narrow border, enclosing a convex area, narrower in front than at the sides. Oblique plications can sometimes be traced on the cheek-plate, in advance of the eye, converging towards the apex of the glabella.

If the associated pygidiums, fig. 8 of Tab. 1A, belong to Trilobites of this species, they are relatively larger than those of any of the above genera. The axal lobe has four segments; side lobes bounded by a slightly concave border, which widens posteriorly, and of which the confines are almost rectangular, with rounded corners.

There are probably at least two species of this genus; one about a third larger than the other. The larger of the two has the glabella less acuminated in front, and more rectangular, and the facial sutures more sinuous; but the distinctive specific characters of the two cannot be well established until more complete specimens are found.

Emended description of species.—Cranidium broad, nearly square in outline; glabella broadly conical, moderately convex; three pairs of glabellar furrows, anterior pair short, nearly obsolete, two posterior pairs broad, shallow, arcuate; a low longitudinal ridge through center of glabella; dorsal furrow deep, broad at sides, shallower across front of glabella; frontal limb of medium width, flat, downsloping to the broad, shallow transverse furrow; frontal border narrow, strongly convex and upturned; anterior margin curved; fixed cheeks slightly less than one-half width of glabella, nearly flat; palpebral lobes medium-sized, prominent, crescentiform, situated on transverse medium line of glabella; palpebral furrow broad, shallow; ocular ridge well defined, extending diagonally across cheeks to near front of glabella; posterolateral limbs of medium width and length with a broad, shallow intramarginal furrow; occipital ring narrow, slightly convex; occipital furrow deep and broad. Free cheek heavy and broad, with good-sized eye at inner angle; ocular platform wide, nearly flat; marginal furrow well defined but shallow; marginal border wide, moderately convex, with a narrow projection anteriorly but expanding posteriorly into a long broad genal spine.

Facial suture cutting anterior margin at sides on line with posterior portion of dorsal furrow, curving out and back to transverse furrow, thence running in a straight line diagonally into and then curving around palpebral lobes; then swinging out and back in a long smooth curve to cut posterior margin just within genal angle.

Thorax not known.

Pygidium broadly transverse, rectangular in outline; axial lobe proportionally narrow, strongly convex, extending somewhat more than one-half length of pygidium and tapering to an acute termination; divided by narrow furrows into four segments and a terminal portion; dorsal furrow narrow, shallow; pleural lobes one and one-half times width of axial, regularly convex, marked by four wide segments, sloping down into the nearly flat marginal border; border narrow anteriorly, expanding rapidly in width posteriorly with a tiny, posteriorly directed spine at each posterolateral corner; posterior margin straight.

Outer and inner surface of test not known.

Remarks.—In 1852 when Owen described the genus *Crepicephalus* he figured several not very well preserved cranidia as representative of his new genus and several pygidia as questionably belonging to the same genus. He stated at the time that he believed two species to be present but he did not describe either nor designate any species as a genotype. Later both Hall and Shumard (see synonymy Walcott, 1916, pp. 199–200) placed the genus in synonymy with *Conocephalites* and apparently knew of no specimens like those figured by Owen. However, in 1877 Hall and Whitfield (1877, p. 209) recognized *Crepicephalus* and referred a number of species from the Eureka district of Nevada to the genus, though none of them actually belong to *Crepicephalus*. Thus, though *Crepicephalus* (*Loganellus*) *haguei* Hall and Whitfield (now *Elrathia haguei* (H. and W.)) actually was the first species to be described under the generic name, neither it nor any of the other species described at that time can be recognized as the genotype. Finally in 1886 Walcott restudied *Crepicephalus*, recognized it as a valid genus, and chose as the genotype the species that was described by Owen in 1852 as *Dikelocephalus? iowensis*, but which actually is congeneric with the species that Owen used as the example of his *Crepicephalus*. It appears that Walcott did not have available Owen's types nor any specimens of *Crepicephalus* from subzone I of the *Crepicephalus* zone from near Trempealeau, the locality of Owen's specimens, or he would have readily noted the specific difference between the forms. The National Museum material, which was so excellently

preserved and which he could demonstrate was Owen's species *Dikelocephalus? iowensis*, was all obtained from subzone III of the *Crepicephalus* zone, where this species is the characteristic form and *C. oweni* does not occur.

Thus it happens that although *Crepicephalus oweni* actually is the species used by Owen to establish the genus, the genotype of *Crepicephalus* is *C. iowensis* (Owen) as chosen by Walcott in 1886.

Occurrence.—Upper Cambrian, Eau Claire member of the Dresbach formation, *Crepicephalus* zone (subzone I, *C. oweni* faunule). Division 3 of section (just above *Cedaria* zone) in quarry in southwest corner of Independence, Trempealeau County; near Trempealeau, Trempealeau County, Wis.

Types.—Holotype, a cranidium, M.P.M. 25050. Paratypes, a pygidium, M.P.M. 25049; a pygidium, M.P.M. 25048; cranidia, free cheeks and fragmentary pygidia, M.P.M. 25051. All from division 3 in section in quarry in southwest corner of Independence, Trempealeau County, Wis.

MODOCIA WALCOTTI Lochman, n. sp.
Plate 35, figures 1, 2

Crepicephalus unca (part) WALCOTT, *1916*, Smithsonian Misc. Coll., vol. 64, no. 3, p. 217, figs. 1, 1a–c.

Uncaspis unca (part) KOBAYASHI, *1935*, Imp. Univ. Tokyo Jour. Fac. Sci., sec. 2, vol. 4, pt. 2, p. 279.

Original description of cranidium.—The associated cranidium is similar in outline to that of *C. dis*, but differs in having proportionally broader fixed cheeks.

Supplementary description.—Cranidium wide, square in outline; glabella conical, strongly convex, with three pairs of faint curved glabellar furrows; dorsal furrow narrow but well defined; frontal limb of medium width, slightly convex, downsloping to narrow shallow transverse furrow; frontal border narrow, slightly convex; anterior margin rounded; fixed cheeks wide, one-half width of glabella, slightly convex; palpebral lobes medium-sized, crescentiform, situated on transverse median line of glabella; palpebral furrows narrow, shallow; posterolateral limb of medium length and width with a broad, shallow intramarginal furrow; occipital ring narrow, nearly flat; occipital furrow well defined at sides, shallow through center. Free cheek of medium width, elongate, with medium-sized eye at inner angle; ocular platform moderately wide, flat; a narrow, shallow marginal furrow; marginal border moderately wide, convex, with a long pointed anterior projection and a medium-length heavy genal spine.

Facial suture cutting anterior margin well out at sides, curving out and back to transverse furrow, then running straight in to palpebral lobes and curving around them; thence curving out and back to cut posterior margin just within genal angle.

Thorax and pygidium not known.

Outer and inner surfaces of test not known.

Remarks.—With the emending and redefinition of the species *Uncaspis unca* (Walcott), the cranidia and free cheek formerly assigned to this species by Walcott are left without a generic or specific designation. They represent an undescribed species of *Modocia*, here named *M. walcotti* Lochman, which is very closely related to the Black Hills species *M. centralis* (Whitfield). The refigured specimens indicate that Walcott's photographs had the glabellar furrows retouched so that they appear to be well defined, whereas actually the glabellar furrows on *Modocia walcotti* are very faintly developed, a feature characteristic of all species of *Modocia*.

The occurrence of a species of *Modocia* in the fauna of subzone III of the *Crepicephalus* zone extends the range of the genus considerably. *Modocia* is especially characteristic of the middle *Cedaria* zone in the Cordilleran region, but in the Black Hills it occurs in an assemblage of either late *Cedaria* or very early *Crepicephalus* zone. Its appearance in subzone I in Wisconsin indicates that the genus was slowly moving eastward along the southern shore of Laurentia during early Upper Cambrian time. Apparently, however, it was never able to penetrate beyond Wisconsin as it has never been recorded from either of these zones or any later zones in Missouri, Texas or the southern Appalachians. It appears to have lingered on in Wisconsin during *Crepicephalus* zone time, and finally disappeared with that fauna.

Occurrence.—Upper Cambrian, Eau

Claire member of the Dresbach formation. *Crepicephalus* zone (subzone I, *C. oweni* faunule). Wisconsin: quarry in southwest corner of Independence, Blair, and Strum, Trempealeau County; quarry on Mt. Washington, Shawton, and Eau Claire, Eau Claire County; Rock Falls and Colfax, Dunn County; Albertsville, Chippewa County; Mondovi, Buffalo County.

Crepicephalus zone (subzone III, *C. iowensis* faunule). U.S.N.M. locality 79c, Willow River, near Hudson, St. Croix County, Wis.

Types.—Holotype, a cranidium, U.S.N.M. 61709; paratype, a free cheek, U.S.N.M. 61710. Both U.S.N.M. locality 79c.

TERRANOVELLA DORSALIS (Hall)
Plate 35, figures 3–10, 17

Conocephalites? (Arionellus?) dorsalis HALL, *1863*, New York State Cab. Nat. History, 16th Ann. Rept., p. 222.
Ptychoparia dorsalis, VODGES, *1890*, U. S. Geol. Sur., Bull. vol. 63, p. 141.
Ptychoparia dorsalis, TELLER, *1911*, Wisconsin Nat. History Soc. Bull., vol. 9, no. 4, p. 267.

Original description.—Several small specimens have been observed, preserving the glabella and fixed cheeks.

Glabella moderately gibbous, minute, truncate-conical, a little wider at base than the length from the occipital furrow, with two distinct slightly oblique furrows, the posterior ones most oblique, and reaching about one-third across the glabella; occipital furrow narrow and well defined; occipital ring wider, more prominent in the middle, and produced into a node (which in the crust has probably been a short spine). Dorsal furrow well defined, and continuing of the same width and strength in front. Fixed cheeks a little wider at base, prominent, and continuing in a convex border in front.

The specimens have the form and aspect of *Arionellus bipunctatus;* but the glabella is more distinctly lobed, and the puncta at the anterior angles do not exist in this one.

Supplementary description.—Cranidium short, subsquare in outline; glabella narrowly conical, moderately convex with two pairs of short, arcuate glabellar furrows; dorsal furrow broad, well defined, shallow at sides but deep and prominent across front of glabella; frontal limb of medium width, strongly convex; no frontal border or transverse furrow; anterior margin curved. Fixed cheeks moderately wide, one-half width of glabella, flat to very slightly convex; palpebral lobes small, situated slightly anterior to transverse median line of glabella; a low, narrow ridge running nearly straight in to front of glabella; posterolateral limbs short, moderately wide, with a shallow intramarginal furrow; occipital furrow narrow, well defined only at sides; occipital ring triangular, flat, extended medially into a slender spine. Free cheek narrow, elongate, with small eye at inner angle; ocular platform narrow, slightly convex; marginal furrow narrow, shallow; a narrow convex marginal border with a short vertical anterior projection and a very short slender genal spine.

Facial suture cutting anterior margin well out at sides, curving out and then running straight in to palpebral lobes, around which it curves; thence curving diagonally out and down to cut posterior margin at genal angle.

Thorax not known.

Pygidium small, transverse; axial lobe relatively wide, strongly convex, tapered and extending nearly full length of pygidium, divided into four segments by deep narrow furrows; dorsal furrow shallow, only at sides of axial lobe; pleural lobes slightly narrower than axial, flat, divided into two or three low segments; marginal border narrow, nearly vertical in position all around.

Outer and inner surface of test not known.

Remarks.—When Hall described this species, he neglected to figure it, and possibly for this reason, it appears to have been forgotten when Walcott restudied many of the Eau Claire species. Likewise, Hall's types appear to have been misplaced and are now apparently lost. Inquiry and careful search have been made at the American Museum of Natural History, the New York State Museum, Walker Museum, University of California Paleontologic Museum, Milwaukee Public Museum, and the University of Wisconsin Museum; but no type specimens appear available. However, the description fits exactly the form which is here referred to this species, and the discovery of a fragmentary cranidium of *Terranovella dorsalis* (Hall) on the slab carrying the paratype of *Millardia optata* (Hall), a specimen which according to Hall came from the same locality and horizon as the types of *Terra-*

novella dorsalis (Hall) and was described at the same time, serves to indicate that specimens of this species were certainly present in the material which Hall studied. With these means of verification, lectotypes, constituting a neoholotype and neoparatypes, have been chosen from the best material at the Milwaukee Public Museum.

This material, containing not only cranidia but also the associated free cheeks and pygidia, furnishes a nearly complete picture of the carapace of *Terranovella*, which, though now widely known from Newfoundland and the southern Appalachians to Montana, has only been described from the cranidium.

The Wisconsin occurrence extends the known stratigraphic range of the genus from the *Cedaria* and basal portions of the *Crepicephalus* zones to the top of the *Crepicephalus* zone.

Occurrence.—Upper Cambrian, Eau Claire member of the Dresbach formation. *Crepicephalus* zone (subzone III, *C. iowensis* faunule). "Near Trempealeau"; Division 4 of section in quarry ¼ mile northeast of brewery, Arcadia, Trempealeau County, Wis.

Types.—Neoholotype, a cranidium, M.P.M. 25053. Neoparatypes: cranidia, M.P.M. 25057, 25052, 25058, 25054; a free cheek and cranidia, M.P.M. 25056; a pygidium, M.P.M. 25059; a free cheek and a pygidium, M.P.M. 25060. All from division 4 in section in quarry ¼ mile northeast of brewery, Arcadia, Trempealeau County, Wis.

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FAUNAS OF THE CAMBRIAN CLOUD RAPIDS AND TREYTOWN POND FORMATIONS OF NORTHERN NEWFOUNDLAND

B. F. HOWELL
Princeton University, Princeton, N. J.

ABSTRACT—The Cloud Rapids and Treytown Pond faunas of the Canada Bay region, northern Newfoundland, are probably of early Medial Cambrian (i.e., Bonnetian) age. The Treytown Pond fauna contains new species of *Paterina* and *Micromitra*. The Cloud Rapids fauna has one new genus and species of annelid worm and two of brachiopods; also two new species of *Lingulella*, one of *Wimanella*, two of *Ehmania*, two of *Kootenia*, and five of other genera of trilobites. Some of the trilobites of the Cloud Rapids fauna resemble species of the Wolsey, Damnation, and Pagoda formations of Montana, and the Cape Wood formation of Greenland, and the faunas of all these formations are probably of much the same age and make possible the correlation of the formations, although they are geographically far distant from each other.

WHEN North American paleontologists discovered the Medial Cambrian faunas of Massachusetts, New Brunswick, and southeastern Newfoundland they found them to be remarkably similar to the faunas of the same age that had been found earlier in northwestern Europe. But, when the American and Canadian paleontologists extended their search to the western part of their continent, they came upon Medial Cambrian faunas of such a different character that it was not possible to correlate them accurately with those of the North Atlantic region. And, although our knowledge of the faunas of this age in both halves of the continent has increased steadily during the past three-quarters of a century, this increase has until recently failed to produce information which would make possible satisfactory correlations of Atlantic Coast faunas with faunas occurring in the Rocky Mountains and the Canadian Cordillera. The discovery in northern and western Newfoundland of faunas of western North American aspect is therefore of great importance. The two faunas of this kind that have been found in northern Newfoundland are here described. Both are from Canada Bay, which is on the eastern side of the northern peninsula of that island.

Alexander Murray (1881), who examined the rocks along the eastern shore of the northern peninsula of Newfoundland in 1864, discovered "Potsdam" trilobites of the genus *Olenellus* on Long Arm, at the northern end of Canada Bay. In beds above those containing *Olenellus* he found "a *Lingula*" which Billings considered to be "a new species, but allied to *L. prima* (Conrad)." Murray believed that all of these beds belonged in a single formation, which he called the Salt Water Pond formation; but Frederick Betz and the writer in 1936 discovered within these beds a disconformity below which the fossils were those of an Early Cambrian Forteau fauna and above which there were not only fossils of two species of *Lingulella* (one of which is probably Billings' "*Lingula*—allied to *L. prima*"), but also other brachiopods and several species of trilobites, two of which are referable to the genus *Ehmania*, which is a characteristic genus of certain Medial Cambrian faunas in the Rocky Mountains. Betz (1939, pp. 15–16) has named these *Ehmania* beds the Cloud Rapids formation.

In 1937 Betz and B. F. Howell, Jr., collected many fossils from this formation and secured brachiopods from limestones, which Betz (1939, pp. 16–17) named the Treytown Pond formation, that overlie the Cloud Rapids beds, apparently conformably, and contain two of the species of brachiopods found in the Cloud Rapids formation, *Paterina rotunda* and *Micromitra cloudensis*. These fossils, now in the paleontological collection of Princeton University, are described herewith.

SYSTEMATIC DESCRIPTIONS

Phylum ANNELIDA
Class CHAETOPODA
Subclass POLYCHAETA
Order TUBICOLA
Family TEREBELLIDAE
Genus TEREBELLITES Howell, n. gen.

Worms whose soft parts are unknown, but which probably resembled those of the modern genus *Terebella*, since they built tubes composed of sand grains. The walls of the tubes were proportionately thicker than are those of the living species of *Terebella*, being in the genotype species as thick as, or thicker than, the diameter of the dwelling cavity within them, and they were solidly and compactly constructed of small grains of sand.

Genotype, *Terebellites franklini* Howell, n. sp.

Range.—Middle and Lower Cambrian. The genotype is from the Cloud Rapids formation. Another species, as yet undescribed, occurs in the Lower Cambrian Forteau formation of western Newfoundland. It will be described in a later paper.

TEREBELLITES FRANKLINI, n. sp.
Plate 36, figure 1

This species is based on the single specimen illustrated. It is notable for the relatively thick walls of its tube and for the fact that both the outer and the inner surfaces of those walls are smooth except for the irregularity resulting from the walls' being composed of small sand grains.

The specific name is given in honor of the author's son, who collected the only known specimen of the species.

Location of type.—The holotype is no. 51116 in the paleontological collection of Princeton University. It is from the Cloud Rapids formation on the eastern side of the entrance to Little Treytown Pond.

Phylum MOLLUSCOIDEA
Class BRACHIOPODA
Order ATREMATA
Superfamily OBOLACEA
Family PATERINIDAE
PATERINA ROTUNDA Howell, n. sp.
Plate 36, figures 2–7

In size and general form this species approaches *Paterina superba* (Walcott) of the western United States Middle Cambrian. It differs from *P. superba* in having the pedicle valve a little less convex and the brachial valve more rounded at the posterior corners. The two species are, however, so similar that the finding of more and better-preserved examples may demonstrate that *P. rotunda* should be classified as a variety of *P. superba*. The brachial valves here referred to *P. rotunda* vary in outline, some of the larger ones being more rotund than others. It is possible that more than one form has been included in the species; but no satisfactory evidence in support of this was found in the collection studied. The largest pedicle valve of *P. rotunda* found is 10 mm. in diameter. Most of the valves are somewhat smaller.

The species is common in both the Cloud Rapids and the Treytown Pond formations. It was collected from the Cloud Rapids formation at the following localities near the northern end of Canada Bay: Cloud Rapids, Barnes Cove (near the foot of Cloud Rapids), the beach west of Barnes Cove, the point between Cloud Rapids and First Tickle Cove, and the northeastern side of Canning's Gase, Long Arm. Specimens were secured from the Treytown Pond formation on the southern side of Big Treytown Pond, near the outlet of the pond.

Observations.—It is often difficult to determine whether incomplete valves of the *Paterina* and *Micromitra* type in our collection are referable to this species or to *Micromitra cloudensis*, described below. *Paterina rotunda* grows larger than *Micromitra cloudensis* and has the pedicle valve less elevated. In well-preserved specimens of *M. cloudensis* the radiating ridges of the ventral valve distinguish it from the smooth pedicle valve of *P. rotunda*.

Location of types.—The holotype is a pedicle valve, no. 50610, in the paleontological collection of Princeton University. Paratypes are nos. 50487, 50488, 50494, 50497, 50585, 50586, 50588, 50589, 50593, 50596–50599, 50602, 50606, 50618, 50619, 50631, 50637, 50638, 60641, 50642, 50644, 50646, and 50650 in the same collection. All are from the Cloud Rapids formation (the holotype being from Barnes Cove, at the foot of Cloud Rapids). Paratypes, also from

the Cloud Rapids formation, are nos. 6462 and 6464 in the Canadian National Museum. Tophomeotypes have been deposited in the paleontological collections of the Academy of Natural Sciences of Philadelphia and the United States National Museum, and in the Walker Museum of the University of Chicago. Onomatypes and homeotypes from the Treytown Pond formation are in the Princeton University collection.

MICROMITRA CLOUDENSIS Howell, n. sp.
Plate 36, figures 8–12

This species has a pedicle valve of average convexity, with the beak somewhat curved over, the radiating ridges on the shell not strongly developed, and the brachial valve wide in proportion to its length. The shells of the specimens have a surface which shines as though it had been polished. The species averages smaller in size than *Paterina rotunda*, the largest pedicle valve known being only 7 mm. in diameter, and the usual diameter being 5 mm.

Observations.—*Micromitra cloudensis* is usually easily distinguishable from *Paterina rotunda* by its smaller size, the somewhat greater convexity of the pedicle valve, and the more polished appearance of the surface of the shell, as well as by the presence of radiating ridges. It is, however, sometimes difficult to decide to which species to assign a given valve, especially if it is fragmentary.

M. cloudensis resembles the early Medial Cambrian species, *M. pealei* (Walcott), in general form and size. It differs from that western North American species in having the radiating ridges less prominent and the beak a little less incurved. It is, however, so close to *M. pealei* as perhaps to deserve to be called a variety of that species.

Bell (1941) has recently discussed the relationships of the genera *Paterina* and *Micromitra* and their classification. The present writer, although he has recognized those genera as distinct and has placed them both in the Atremata, realizes that future workers may dispose of them in a different way.

Micromitra cloudensis is somewhat less common than *Paterina rotunda* in the Cloud Rapids formation, but is more common than the latter species in the Treytown Pond formation. The species was collected from the Cloud Rapids formation at Cloud Rapids, at Barnes Cove (at the foot of Cloud Rapids), at the beach west of Barnes Cove, and on the northeastern side of Canning's Gase (on Long Arm). The specimens collected from the Treytown Pond

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EXPLANATION OF PLATE 36

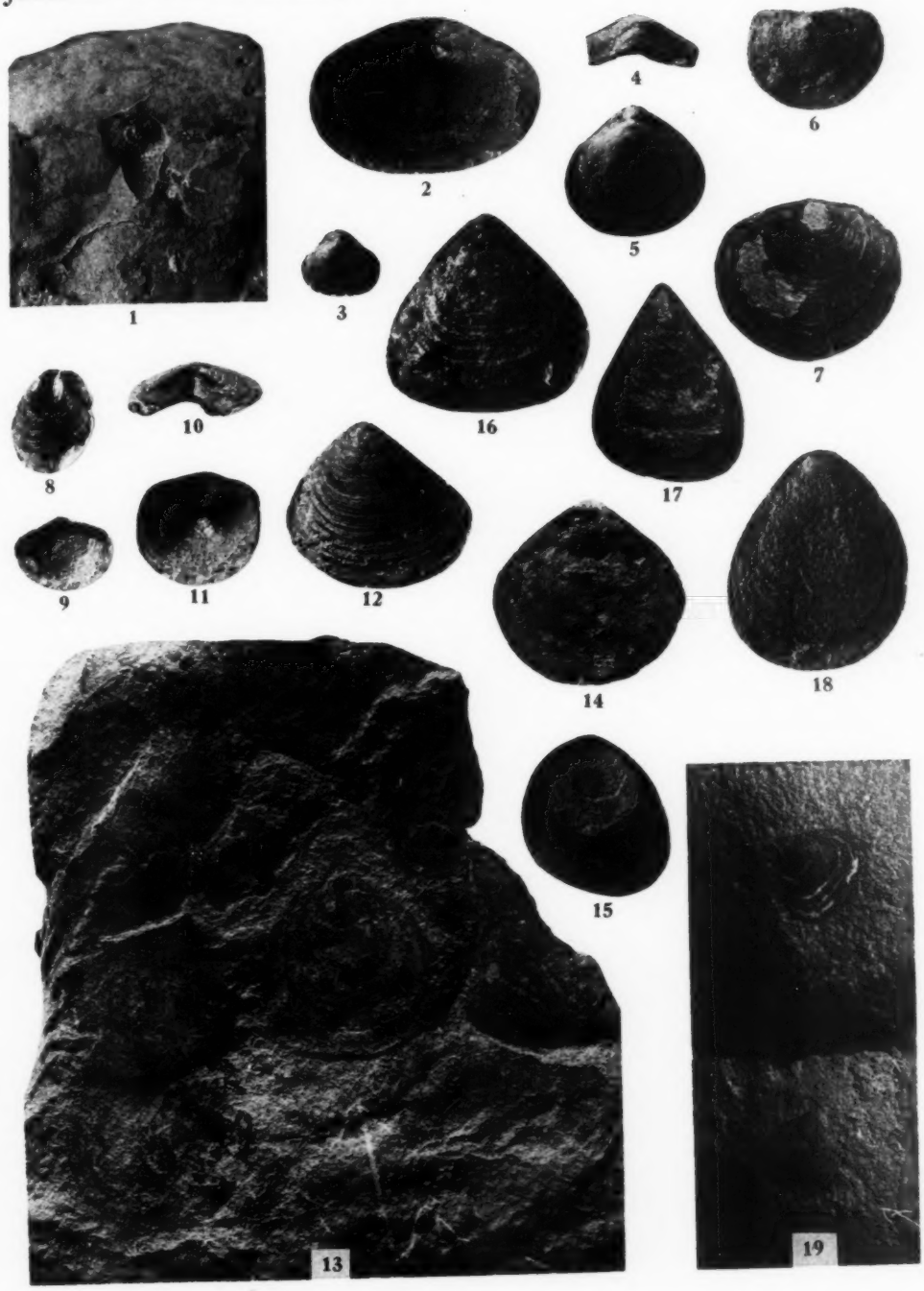
FIG. *1*—*Terebellites franklini* Howell, n. gen., n. sp. Holotype, Princeton 51116, ×3. Middle Cambrian, Cloud Rapids formation. Little Treytown Pond, Canada Bay, Newfoundland. (p. 237)

2–7—*Paterina rotunda* Howell, n. sp. *2*, Holotype, apical view of large ventral valve, Princeton 50610, ×4. *3*, Paratype, apical view of small ventral valve, Princeton 50602, ×4. *4*, *5*, Paratypes, posterior and apical views of ventral valve, Princeton 50599, ×4. *6*, Paratype, apical view of dorsal valve, Princeton 50644, ×4. *7*, Paratype, apical view of large dorsal valve, Princeton 50585, ×4. Middle Cambrian, Cloud Rapids formation. Canada Bay, Newfoundland. (p. 237)

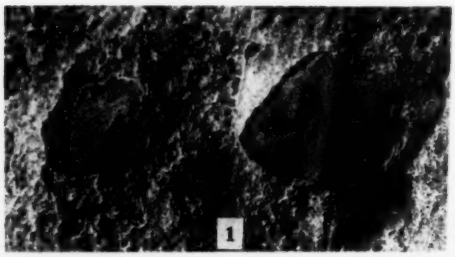
8–12—*Micromitra cloudensis* Howell, n. sp. *8*, Holotype, apical view of ventral valve, Princeton 50652a, ×4. *9*, Paratype, apical view of ventral valve, Princeton 50625, ×4. *10*, *11*, Paratypes, posterior and apical views of ventral valve, Princeton 50660, ×4. *12*, Paratype, diagonal apical view of large ventral valve, Princeton 50657, ×4. Middle Cambrian, Cloud Rapids formation. Cloud Rapids, Canada Bay, Newfoundland. (p. 238)

13–15—*Lingulella borealis* Howell, n. sp. *13*, Holotype pedicle valve (indicated by arrow) and paratype pedicle and brachial valves, Princeton 50664, ×4. *14*, Paratype pedicle valve, Princeton 50666, ×4. *15*, Paratype brachial valve, Princeton 50676, ×4. Middle Cambrian, Cloud Rapids formation. Big Treytown Pond, Canada Bay, Newfoundland. (p. 239)

16–19—*Lingulella terranovica* Howell, n. sp. *16*, Paratype, pedicle valve, Princeton 50473, ×4. *17*, Paratype, pedicle valve, Princeton 50477, ×4. *18*, Paratype, brachial valve, Princeton 50454, ×4. *19*, Holotype pedicle valve (above) and paratype brachial valve (below), Princeton 50705a, b, ×2. Middle Cambrian, Cloud Rapids formation. Canada Bay, Newfoundland. (p. 239)



Howell, Cambrian Fossils from Newfoundland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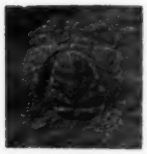
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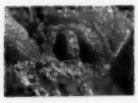
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Howell, Cambrian Fossils from Newfoundland

formation were all secured from the southern side of Big Treytown Pond, near its outlet (on Long Arm).

Location of types.—The holotype, a pedicle valve, is no. 50652a in the paleontological collection of Princeton University. It is from the Cloud Rapids formation at Barnes Cove, at the foot of Cloud Rapids. Paratypes are nos. 50438, 50495, 50590, 50613, 50620, 50622, 50624, 50625, 50627, 50633, 50634, 50643, 50645, 50651, 50652b–f, 50653, 50657, 50659, 50660, in the same collection. All are from the Cloud Rapids formation. Tophomeotypes from the Cloud Rapids formation have been deposited in the paleontological collection of the Academy of Natural Sciences of Philadelphia. Onomatypes and homeotypes from the Treytown Pond formation are also preserved in the Princeton collection.

Family OBOLIDAE

LINGULELLA BOREALIS Howell, n. sp.

Plate 36, figures 13–15

Both valves are almost circular in form, with thin shells of very low convexity. The beak of the ventral valve is so little extended that it is often difficult to tell the two valves apart. Specimens preserved in shale are completely flattened. The concentric lines of growth are conspicuous. Little can be seen of the internal markings in the specimen studied.

Observations.—Although little is known of the internal characters of this species, the general form of the shells indicates that it is referable to *Lingulella*. It resembles in form and size the Upper Cambrian species *Lingulella* (*Bröggeria*) *salteri* (Hall); but it does not show the internal characters that distinguish *Bröggeria*, and it is a much older species than *L.* (*B.*) *salteri*. The writer knows of no other species with which it can be compared, for its pedicle valve is less pointed at the beak end than are the ventral valves of most other species of *Lingulella*.

Walcott referred Cambrian brachiopods of this kind to the genus *Obolus;* but Resser (1938) has recently recommended that they be assigned to *Lingulella*. The writer agrees with Resser and has followed his recommendation in the cases of this and the next described species.

L. borealis has not been found in association with any other fossils. The beds in which it occurs are gray shales believed to be near the base of the Cloud Rapids formation. Specimens were collected from the point between Cloud Rapids and First Tickle Cove, from the entrance to Big Treytown Pond, and from the entrance to Little Treytown Pond.

Location of types.—The holotype, a pedicle valve, is no. 50664a in the paleontological collection of Princeton University. It is from the Cloud Rapids formation at the entrance to Big Treytown Pond. Paratypes are nos. 50445–50449, 50664b–n, 50665–50670 and 50674–50694 in the same collection.

LINGULELLA TERRANOVICA Howell, n. sp.

Plate 36, figures 16–19

Lingula, n. sp. BILLINGS, MURRAY, and HOWLEY, *1881*, Geological Survey of Newfoundland, p. 11.

EXPLANATION OF PLATE 37

FIGS. *1, 2*—*Wimanella terranovica* Howell, n. sp. *1*, Holotype brachial valve (at right) and pedicle valve (at left), Princeton 50719a, b, ×2. *2*, Squeeze of holotype brachial valve, ×2. Middle Cambrian, Cloud Rapids formation. Canada Bay, Newfoundland. (p. 240)

3–13—*Ehmania borealis* Howell, n. sp. *3*, Paratype cranidium, Princeton 50865, ×1. *4*, Paratype small cranidium, Princeton 50861, ×1. *5*, Paratype cranidium, Princeton 50723, ×1. *6*, Paratype pygidium, Princeton 50491, ×2. *7*, Paratype cranidia, Princeton 50858, ×2. *8*, Paratype cranidium, Princeton 50731, ×3. *9*, Paratype thorax and pygidium, Princeton 51049, ×1. *10*, Paratype young cephalon, Princeton 50468, ×2. *11*, Paratype young cranidium, Princeton 50468, ×2. *11*, Paratype young cranidium, Princeton 50402, ×4. *12*, Holotype cranidium, Princeton 50736, ×4. *13*, Paratype young cephalon, Princeton 50862, ×5. Middle Cambrian, Cloud Rapids formation, Canada Bay, Newfoundland. (p. 240)

14—*Ehmania cloudensis* Howell, n. sp. Holotype cranidium, Princeton 50875, ×3. Middle Cambrian, Cloud Rapids formation, Long Arm, Canada Bay, Newfoundland. (p. 241)

The ventral valve of this species is subtriangular in outline, and the shell is somewhat thicker than that of *Lingulella borealis*. The brachial valve is egg-shaped in outline. Nothing is known of the internal markings of the valves.

Observations.—In form this species is intermediate between a typical *Obolus* and a typical *Lingulella*. As the internal markings of the shells are unknown, it is not possible to determine from them with certainty in which of the two genera the species belongs. It is placed in *Lingulella* in accordance with the practice recommended by Resser. It appears to resemble *Lingulella tetonensis nina* (Walcott) more than any other brachiopod, being somewhat more circular in outline (relatively wider for its length) than are most species of *Lingulella*, and having the front border of the pedicle valve straighter (less rounded) than is usual in *Lingulella*. In this respect and in the pointed beak of its ventral valve *L. terranovica* resembles the species of the subgenus *Lingulepis* of the genus *Lingulella*, although these characters are less accentuated in our form than in the species that are placed in *Lingulepis*. It is possible that *L. terranovica* is closely related to some of the earlier forms of *Lingulepis;* but for the present it seems best to assign it tentatively to *Lingulella* and to leave the final determination of its systematic position to be made when specimens showing the internal markings have been discovered.

There is some variation in the form of the shell of the ventral valve of our species among the specimens in hand. Although this variation is due in part to differences in the amount of flattening which the shells have suffered, it must be due also in part to original differences in form.

L. terranovica differs from *L. tetonensis nina* (Walcott) in being somewhat smaller in size and in having the front edge of the pedicle valve straighter. *L. tetonensis nina* is found in the Upper Cambrian of the western United States. It, like *L. terranovica*, varies in form, some of its shells being almost identical in shape with some valves of that species; and it is possible that the Newfoundland species is an ancestor of the western one.

It was probably *L. terranovica* that Murray found at Canada Bay in 1864, and specimens of which Billings examined and considered to be a new species allied to "*Lingula*" *prima*.

L. terranovica has been found only in limestones of the Cloud Rapids formation on the point between Cloud Rapids and First Tickle Cove. It is at that locality sometimes associated with the trilobite *Ehmania borealis*.

Location of type.—The holotype, a pedicle valve, is no. 50705a in the paleontological collection of Princeton University. Paratypes are nos. 50452, 50454, 50456, 50463, 50472–50474, 50477, 50478, 50480, 50704, 50705b, 50706, 50709–50711, 50713–50717, and 50726 in the same collection.

Order PROTREMATA
Superfamily ORTHACEA
Family EOORTHIDAE
WIMANELLA TERRANOVICA
Howell, n. sp.
Plate 37, figures 1, 2

Known only from the holotype brachial valve and a fragment of a pedicle valve which occurs with it in a piece of gray limestone of the Cloud Rapids formation from the point between Cloud Rapids and First Tickle Cove.

The brachial valve is moderately convex, with a shallow sinus, very faint traces of ribbing, and short but distinctly extended and pointed cardinal angles. The fragment of the pedicle valve is too incomplete for description.

Observations.—This species is similar to *Wimanella anomala*, which occurs in the Conasauga formation of Alabama, but differs in having the edge of the shell less indented in front of the cardinal angles.

Location of types.—The holotype brachial valve is no. 50719a in the paleontological collection of Princeton University. The single known paratype, a pedicle valve, is 50719b in the same collection.

Phylum ARTHROPODA
Class CRUSTACEA
Subclass TRILOBITA
Family PTYCHOPARIDAE
Subfamily PTYCHOPARINAE
EHMANIA BOREALIS Howell, n. sp.
Plate 37, figures 3–13

Cranidium: The brim is almost flat, with only a little thickening and convexity. It is separated from the rest of the cranidium by a well-developed but shallow furrow. The glabella and fixed cheeks are moderately convex. The eye is small, and the line extending from it to the dorsal furrow is very faint. The distance from the front end of the well-developed dorsal furrow to the furrow that sets off the brim is less than the width of the brim. There is no neck spine and no well-developed tubercle on the neck ring. There are four degenerate glabellar furrows, which are clearly visible only on peeled specimens, and on those specimens they extend only a short distance inward from the dorsal furrow. Some cranidia have very small closely spaced tubercles on their surfaces, which are arranged on the anterior portion of the fixed cheeks in rows that radiate out from the dorsal furrow.

Free cheeks: The border is broad and only slightly convex. It is separated by a distinct but shallow furrow from the rest of the cheek, which slopes gently up to the eye notch. The spine is short and acutely pointed.

Thorax: No complete thorax has yet been discovered. The few incomplete ones available indicate that there were at least 13 segments.

Pygidium: There are 5 segments in the axis and four segments on the pleural lobes, each with a well-developed pleural groove.

Observations.—This species appears to be clearly referable to the western North American genus *Ehmania* and is thus a good index species for transcontinental correlation purposes. It is the commonest trilobite in the Cloud Rapids formation, having been found at Cloud Rapids, Barnes Cove, just west of Barnes Cove, on the Point between Cloud Rapids and First Tickle Cove, and on the straight shore of Long Arm opposite the small low island that lies there. It can be distinguished from *Ehmania cloudensis*, which occurs with it and is described below, by the fact that, when any tubercles can be seen on the surface of *borealis*, they are very small and are so inconspicuous that they can seldom be detected, while they are much higher and are easy to see on the test of *cloudensis*. Very young cranidia have the brim narrower and more convex than do adult ones.

Location of types.—The holotype cranidium, which came from the Cloud Rapids formation on the point between Cloud Rapids and First Tickle Cove, is no. 50736 in the paleontological collection of Princeton University. Paratypes are nos. 50396, 50402, 50420, 50421, 50450, 50451, 50453, 50461, 50462, 50464, 50467, 50468, 50471, 50473, 50481, 50483, 50484, 50491, 50600, 50611, 50617, 50628, 50720, 50723–50725, 50728–50733, 50735–50738, 50740, 50741, 50856–50866, 50869, 50870, 50888, 50890, 50891, 51049, 51051, and 51114 in the Princeton collection, and nos. 6463–6465 in the paleontological collection of the Canadian National Museum. Tophomeotypes have also been deposited in the United States National Museum and in the Walker Museum of the University of Chicago.

EHMANIA CLOUDENSIS Howell, n. sp.
Plate 37, figure 14, plate 38, figures 1–5

Cranidium: Like that of *Ehmania borealis*, except that it is covered with well-developed though not large tubercles, which are visible to the naked eye, while those of *E. borealis* are too small to see without the aid of a microscope and are usually invisible even with such an aid to vision. On the anterior part of the fixed cheeks these tubercles are often, as they sometimes are in *E. borealis*, arranged in rows which radiate outward, fanwise, from the dorsal furrow. This would appear to indicate a ptychoparoid relationship, as such rays, usually in the form of thin ridges, are characteristic of *Ptychoparia*.

Free cheeks: Like those of *E. borealis* except that, as in the case of the cranidium, the test is covered with prominent tubercles.

Thorax: Similar to that of *E. borealis*, except that the surface is covered with prominent small tubercles. No complete thorax has been found; but incomplete ones in hand indicate that there were at least 13 segments. The ends of the pleura are rather bluntly pointed.

Pygidium: Like that of *E. borealis* except that it has the tubercles characteristic of *E. cloudensis*.

Observations.—It is possible that this species is identical with *E. borealis*, and that

the prominent tubercles which seem to distinguish it from that species are merely sexual characters. This is not impossible, but it is made the less probable by the fact that, while the two forms do occur together at Cloud Rapids, Barnes Cove, and the beach west of Barnes Cove, most of the specimens of *cloudensis* were collected from a bed in the Cloud Rapids formation on the northeastern side of Canning's Gase, on Long Arm (the type locality for the species), where *E. borealis* has not been found.

This species would probably be placed by Deiss in his genus *Clappaspis;* but it so closely resembles *Ehmania borealis* that it seems best to assign it to the same genus as that species.

Location of types.—The holotype cranidium is no. 50875 in the paleontological collection of Princeton University. Paratypes are nos. 50485, 50601, 50603, 50605, 50615, 50616, 50625, 50626, 50629, 50630, 50635, 50636, 50658, 50771–50874, 50876–50878, 50881, 50882, and 50884–50887, 50889, and 50892–50905 in the same collection.

GLYPHASPIS ATLANTICA Howell, n. sp.
Plate 38, figures 6–10

Cranidium: Glabella of moderate convexity, relatively small, with three incomplete furrows and a well-defined neck ring. It tapers forward and is rather squarely terminated at its anterior end. The fixed cheeks are moderately convex and bend downward toward their extremities. They are crossed by eye lines, which grow increasingly prominent as they leave the glabella. The eyes are short but large and prominent. The fixed cheeks meet in front of the glabella in a narrow convex ridge; but the portion of the cranidium anterior to that ridge is concave, so that the brim is turned upward at the front. The test is covered with prominent tubercles, which are not present on exfoliated specimens.

Free cheeks: Moderately convex except where bent sharply upward to meet the eye. The brim is rather narrow. The spine is about one-third the length of the whole cheek and is narrow and acutely pointed.

Thorax and pygidium unknown.

Observations.—The cranidium of this species resembles that of *Glyphaspis capella* (Walcott), from the lower Middle Cambrian Wolsey shale of Montana but differs in being smaller and in having the parts of the shield lying in front of the glabella somewhat narrower.

Glyphaspis capella has been recorded by Poulsen from the lower Middle Cambrian Cape Wood formation of Greenland. Other species of *Glyphaspis* are members of the faunas of the Meagher and Pagoda formations of Montana, in which *Ehmania* is also a common genus.

Location of types.—The holotype cranidium is no. 50143 in the Princeton University collection. Paratypes are nos. 50420, 50457, 50469, 50476, 50712, 50722, and 51044–51048 in the same collection. All were collected from the Cloud Rapids formation on the point between Cloud Rapids and First Tickle Cove, Canada Bay.

ANOMALOCEPHALUS? TERRANOVICUS
Howell, n. sp.
Plate 38, figure 11

Cranidium: The single fragmentary cranidium that is the only example of this species that has been found has a gently tapering, moderately convex, glabella, which is bluntly rounded at the front. The neck ring is large but appears to have borne no spine. The fixed cheeks are about as convex and wide as the glabella, and each is crossed by a ridge, which runs diagonally backward from a point just back of the anterior corner of the glabella, at an angle of about 45° to the axis of the glabella, to the eye. The eye is thick, about one-third as long as the glabella, and is set up above the level of the cheek. The fixed cheeks are widely confluent and are convex in front of the glabella. The dorsal furrow is wide, but not deep; it is deepened into a shallow pit in front of the glabella. The test is sprinkled with large tubercles, which are not all of the same size. An evenly spaced row of these tubercles runs across the confluent part of the fixed cheeks, in front of the glabella. There are also tubercles on the ridges which cross the fixed cheeks; but these are not arranged in a definite line.

Free cheeks, thorax, and pygidium unknown.

Observations.—This cranidium appears to be referable to *Anomalocephalus* Deiss (1939), which occurs in the Middle Cambrian of Montana, although it is so incomplete that its reference to that genus must be looked upon as tentative.

Location of holotype.—No. 51103 in the Princeton collection. Collected from the Cloud Rapids formation on the point between Cloud Rapids and First Tickle Cove, Canada Bay.

Family SOLENOPLEURIDAE
Subfamily SOLENOPLEURINAE
SOLENOPLEURA PROAVITA Howell, n. sp.
Plate 38, figures 12–17

Cranidium: Moderately convex, with a smooth test. Glabella tapering only a little, bluntly truncated at the front, and indented by three incomplete furrows, the rear one of which curves backward toward the neck ring, and the anterior one of which is very poorly developed. The fixed cheeks are in some specimens almost confluent in front of the glabella; in others they are less nearly so. The brim is convex, so that it has the appearance of being thick; it is a little wider in front of the glabella than elsewhere, and it is separated from the rest of the cranidium by a wide, shallow, groove. The eyes are small and the ocular ridge is only slightly developed.

Free cheeks: Of the usual *Solenopleura* type, with no genal spines.

Thorax: Composed of 10 segments in the few entire specimens that have been found, with the possible exception of one test, which may have 11. The pleura are rather short, grooved, and bluntly terminated, as is commonly the case in the genus.

Pygidium: Small and much wider than long, of the type characteristic of *Solenopleura*.

Observations.—This species is small for a *Solenopleura* and perhaps represents an early stage in the evolution of that genus. It is comparable in size to *Solenopleurella ulrichi* Poulsen, from the lower Middle Cambrian Cape Wood formation of Northwest Greenland, but differs from that species in having a much wider and more strongly developed brim and a more tapering glabella. It also resembles *Solenopleurella pagodensis* Deiss, from the lower Middle Cambrian Damnation formation of Montana, but differs in having three instead of four glabellar furrows and in the greater development of its brim. It resembles an undescribed species of the fauna of the Middle Cambrian Meagher formation of Montana, but differs in having a somewhat more tapering glabella and narrower fixed cheeks. It also resembles *Solenopleura pauperata* Walcott, of China, and *Solenopleurella buttsi* Resser, from the lower Middle Cambrian Rutledge formation of Virginia.

It is possible that this species is not congeneric with *Solenopleufa holometopa* Angelin, the genotype of *Solenopleura*, whose home is the higher *Paradoxides* beds of Scandinavia, and which therefore lived at a somewhat later time than our species. *Solenopleura* has commonly been made to include such a variety of forms, however, that ours (and also possibly *Solenopleurella pagodensis*) would seem to be properly placed with them. A careful study of a large collection of specimens of all the species which have been assigned to the genus *Solenopleura* would probably lead to the splitting of them into at least two groups of generic or subgeneric rank. Perhaps such species as *proavita* and *pagodensis* represent an intermediate stage in evolution between *Solenopleura* and *Solenopleurella*. Specimens of *Solenopleura proavita* were found in the Cloud Rapids formation at Cloud Rapids and Barnes Cove. The holotype test is from Cloud Rapids. A pygidium tentatively assigned to this species was found on the point between Cloud Rapids and First Tickle Cove.

Location of types.—The holotype test is no. 51053a in the Princeton collection. Paratypes are nos. 51053b–o, 50587, 50591, 50595, 50632, 50649, 50654, and 51053–51063 in the same collection. The pygidium from the point between Cloud Rapids and First Tickle Cove, referred to above, is no. 50418 in that collection also.

SOLENOPARIA? NEWFOUNDLANDENSIS
Howell, n. sp.
Plate 39, figure 1

Cranidium: The cranidium of the only example that has been found is moderately

convex and appears to have been smooth. The glabella tapers gently and is evenly rounded at the front. It is not well enough preserved to show whether it had furrows. The fixed cheeks are only half as wide as the glabella and are confluent in front of the glabella. The eyes are small. The dorsal furrow is well developed throughout. The brim is convex and is separated from the rest of the cranidium by a shallow and narrow groove.

Free cheeks: As wide as the fixed cheeks, with narrow brim and with genal spines that are as long as the glabella.

Thorax: Has eight or more segments, whose pleura are marked by well-developed grooves.

Pygidium: Not preserved on the single known specimen; but a faint trace of its rear border and the position of the last thoracic segment preserved indicate that it was relatively small and probably of the sort characteristic of the Solenopleuridae.

Observations.—As nearly as can be determined from the single test available this species is referable to Kobayashi's genus *Solenoparia*.

Location of holotype.—No. 51104 in the Princeton collection. Collected from the Cloud Rapids formation on the straight shore of Long Arm, Canada, opposite a small, low island which lies there.

Family ELLIPSOCEPHALIDAE
Subfamily AGRAULINAE
MEGAGRAULOS? TERRANOVICUS
Howell, n. sp.
Plate 39, figures 2, 3

Cranidium: Of moderate convexity, with a smooth test. The glabella is about as convex above the level of the fixed cheeks as the cheeks are above a horizontal plane. The glabella is rather short and somewhat bluntly truncated at the front. The dorsal furrow is weak, but the glabella rises so much above the cheeks that it is clearly defined all around. The neck ring is well developed but seems not to have borne any spine. Each fixed cheek is two-thirds as wide as the glabella. The eyes are small. No eye line can be seen crossing the cheeks of either of the two known cranidia. There appears to have been no brim; but the imperfect preservation of the only cranidia that have been found makes impossible a certain statement about this feature of the cranidium.

Free cheeks, thorax, and pygidium unknown.

Observations.—This species appears to be referable to Kobayashi's genus *Megagraulos*, the genotype of which, *Megagraulos coreanicus*, is found in the Middle Cambrian of eastern Asia. Our two specimens came from the Cloud Rapids formation on the northeastern side of Canning's Gase, on Long Arm.

Location of types.—The holotype cranidium is Princeton no. 51105. The paratype no. 51106.

Family ORYCTOCEPHALIDAE
Subfamily ORYCTOCEPHALINAE
KOOTENIA LONGISPINA Howell, n. sp.
Plate 39, figures 4–6

Cranidium: Glabella quadrate, almost straight across the front. The three incomplete glabellar furrows well incised. Dorsal furrow clear, but not deep, with the pits near the anterior corners of the glabella well developed. Brim and fixed cheeks of usual *Kootenia* type; eyes not preserved on the single known cranidium. Test smooth.

Free cheeks and thorax unknown.

Pygidium: Known from only two fragmentary specimens (one a young one), in neither of which is the axis preserved. Four pleural lobes, with faint grooves, and four long, acutely pointed spines. The front edges of the pygidium are also prolonged into acute spines, but these are much shorter than the other spines.

Observations.—This species is remarkable for the length of the spines on its pygidium. In this respect it resembles *Kootenia tetonensis* (Miller), from the lower Middle Cambrian Wolsey formation of Wyoming, though it differs from that species in form. It somewhat resembles an *Olenoides* and may be one of the species of *Kootenia* which was on or near the ancestral line of that genus. The three known examples of our species are all in a single piece of limestone, which was collected at Cloud Rapids.

Location of types.—The holotype is the cranidium, no. 51112a in the Princeton collection. The two paratype pygidia are nos. 51112b and c. All are from the Cloud Rapids formation at Cloud Rapids.

KOOTENIA CLOUDENSIS Howell, n. sp.
Plate 39, figures 7–9

Cranidium: The glabella expands only a little at the front. The three incomplete glabellar furrows and the neck furrow are faint. There is a short upturned spine on the neck ring. The dorsal furrow is well defined throughout, and the pits on it at the anterior corners of the glabella are well developed. Each fixed cheek is less than half as wide as the glabella. The eyes are small. The brim is narrow and turned upward.

The whole cranidium is moderately convex, and the whole test is smooth. The glabellas of young cranidia are less expanded than are those of adult heads.

Free cheeks: Narrow, with a thickened brim and a long spine. The portion opposite the eye is the widest part, but it is also narrow, and that part of the cheek which is anterior to it is only a little wider than the brim, itself.

Thorax unknown.

Pygidium: Moderately convex, with all the parts well developed. Three pairs of distinct pleural lobes and main lobes in the axis, with, in addition, another pair of rudimentary pleural lobes and an elongate rear lobe on the axis that shows faint traces of segmentation. Flange narrow, with five short spines on each side. The young pygidia at hand do not differ in any important respect from the adult ones.

Observations.—Only a few examples of this species have been found. They were collected from the eastern side of the entrance to Little Treytown Pond. The species somewhat resembles *Kootenia latidorsata* Deiss, from the lower Middle Cambrian Damnation formation of Montana, but differs in shape, the glabella and pygidium of the Newfoundland form being longer in proportion to the width of the animal than in the Montana species. The pygidium of *Kootenia cloudensis* also resembles that of *Kootenia resseri* (Poulsen), from the Cape Wood formation of Northwest Greenland; but the axis of the Newfoundland species has more segments and is narrower at the rear than that of the Greenland form.

Location of types.—The holotype is a cranidium, no. 51107a in the Princeton collection. Paratypes are nos. 51107b–n, 51108–51110, and 51115 in the same collection. All are from the Cloud Rapids formation on the eastern side of the entrance to Little Treytown Pond. A single fragmentary pygidium, possibly also referable to this species, found at Barnes Cove, at the foot of Cloud Rapids, is no. 51111 in the same collection. It is also from the Cloud Rapids formation.

Order AGNOSTIA?
AGNOSTIAN?, genus and species undetermined
Plate 39, figure 10

A problematical fossil, which may be the cephalon of a species of agnostian, was found on a piece of Cloud Rapids limestone collected from the beach just west of Barnes Cove. It is rather more convex than the average agnostian cephalon, its convexity is even, as measured from side to side; but the shield slopes downward in a gentle curved arc from the rear to the frontal margin. There is a narrow brim visible around the front end of the shield; but the fossil is so poorly preserved that it is impossible to determine whether this brim extends back along the sides to the rear corners. There are no traces of a glabella, dorsal furrow, tubercle, or basal lobes.

It is impossible to state with certainty that this fossil is that of the cephalon of an agnostian; but such parts of it as are preserved would appear to indicate that it is. The agnostian described by the writer (Howell, 1925) as *Agnostus barlowi definitus*, which is found in the *Paradoxides bennetti* beds of Manuels, southeastern Newfoundland, has a cephalon much like our problematical fossil in form. The beds in which that fossil occurs are believed to be somewhat younger than, but not a great deal younger than, those of the Cloud Rapids formation, and our Cloud Rapids specimen may be the remains of an ancestor of the Manuels species, which is, itself, probably ancestral to other species which occur in later beds of Paradoxidian Cambrian age in Newfoundland and Europe. Until our Cloud Rapids specimen can be proved to be an agnostian cephalon and the pygidium that belongs with it is discovered, however, it seems best not to give it a name or to assign it to a genus.

The specimen is no. 51113a in the Princeton collection.

Problematicum
Plate 39, figure 11

Two peculiar cornucopia-shaped fossils, which somewhat resemble each other and may belong in the same genus, although they are certainly not referable to a single species, are included in the collection secured from the Cloud Rapids formation. They are Princeton nos. 51116 and 51117.

Specimen 51116 was collected from beds on the eastern side of the entrance of Little Treytown Pond. It looks at first glance like a sponge; but it is composed of sand grains, not of spicules. The wall is a little thicker than the cavity within it. There is a dark film on the outer surface of that part of the wall which is imbedded in the rock. This fossil is believed to be the tube of an annelid worm of the family Terebellidae or a related family, and it has been described as such on an earlier page.

Specimen 51117, which was collected from the beach west of Barnes Cove, is larger than specimen 51116, but its wall is of approximately the same thickness as the wall of the other, and the cavity within it is consequently larger. Its body is composed of finer grains than is the body of the other specimen, and the grains, while apparently of some substance less soluble than the limestone in which the fossil is embedded, may not be grains of quartz sand. No film is visible on the outer surface of the wall of this specimen, but there is a faint indication of tiny projecting spicules or septa around the inner edge of the lip.

Specimen 51116 resembles in form and composition the tubes built by worms of the modern marine genera *Sabellaria* and *Terebella*, and it may well be the tube of a marine worm of some such kind. Specimen 51117 may also be a worm of the same sort, although the faint indications of teeth or septa around the inner edge of the lip and the fact that it is perhaps not composed of agglutinated grains of quartz sand may be evidence that it is not the tube of a worm but rather the remains of a coelenterate related to the corals or sea anemonies. Although it resembles some of the Archaeocyathidae in general form, it is not enough like them in detailed structure and composition to make it probable that it is referable to that group. Because of his doubt concerning its relationships the author has not assigned a name to this specimen.

Correlation

Some of the trilobites of the Cloud Rapids fauna—especially *Ehmania borealis*—are so similar to species found in the rocks of the lower Middle Cambrian (i.e., Bonnetian) Wolsey, Damnation, and Pagoda formation, of Montana that the Cloud Rapids fauna and the faunas of those formations must be of much the same age. It is probable that the Cloud Rapids and Treytown Pond faunas are somewhat older than the fauna of the lower beds of the *Paradoxides bennetti* zone

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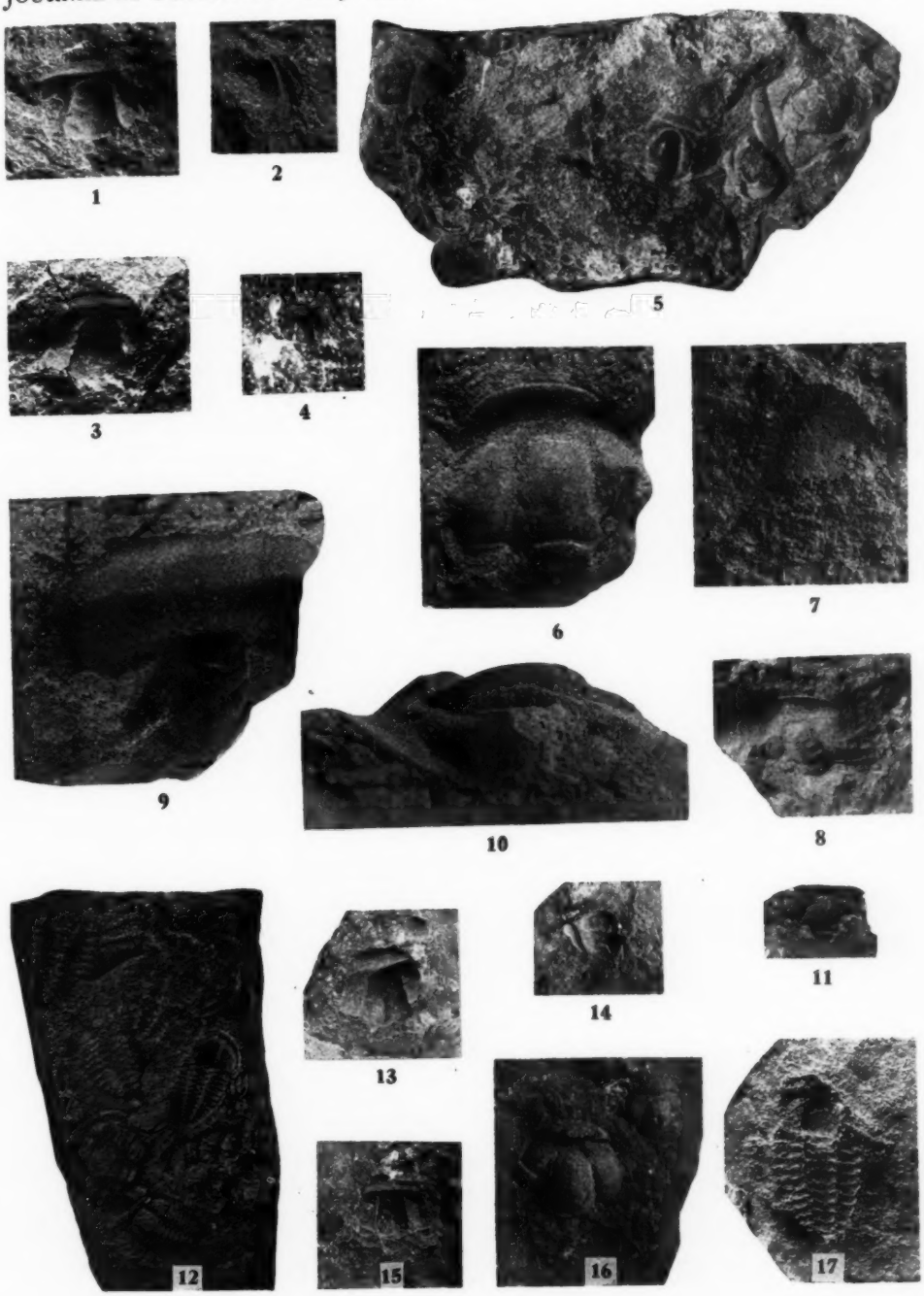
Explanation of Plate 38

Figs. *1–5—Ehmania cloudensis* Howell, n. sp. *1*, Paratype cranidium, Princeton 50629, ×2. *2*, Paratype free cheek, Princeton 50605, ×1. *3*, Paratype young cranidium, Princeton 50900, ×4. *4*, Paratype young cranidium, Princeton 51117, ×4. *5*, Paratype young and adult cranidia, ×2. Middle Cambrian, Cloud Rapids formation. Canada Bay, Newfoundland. (p. 241)

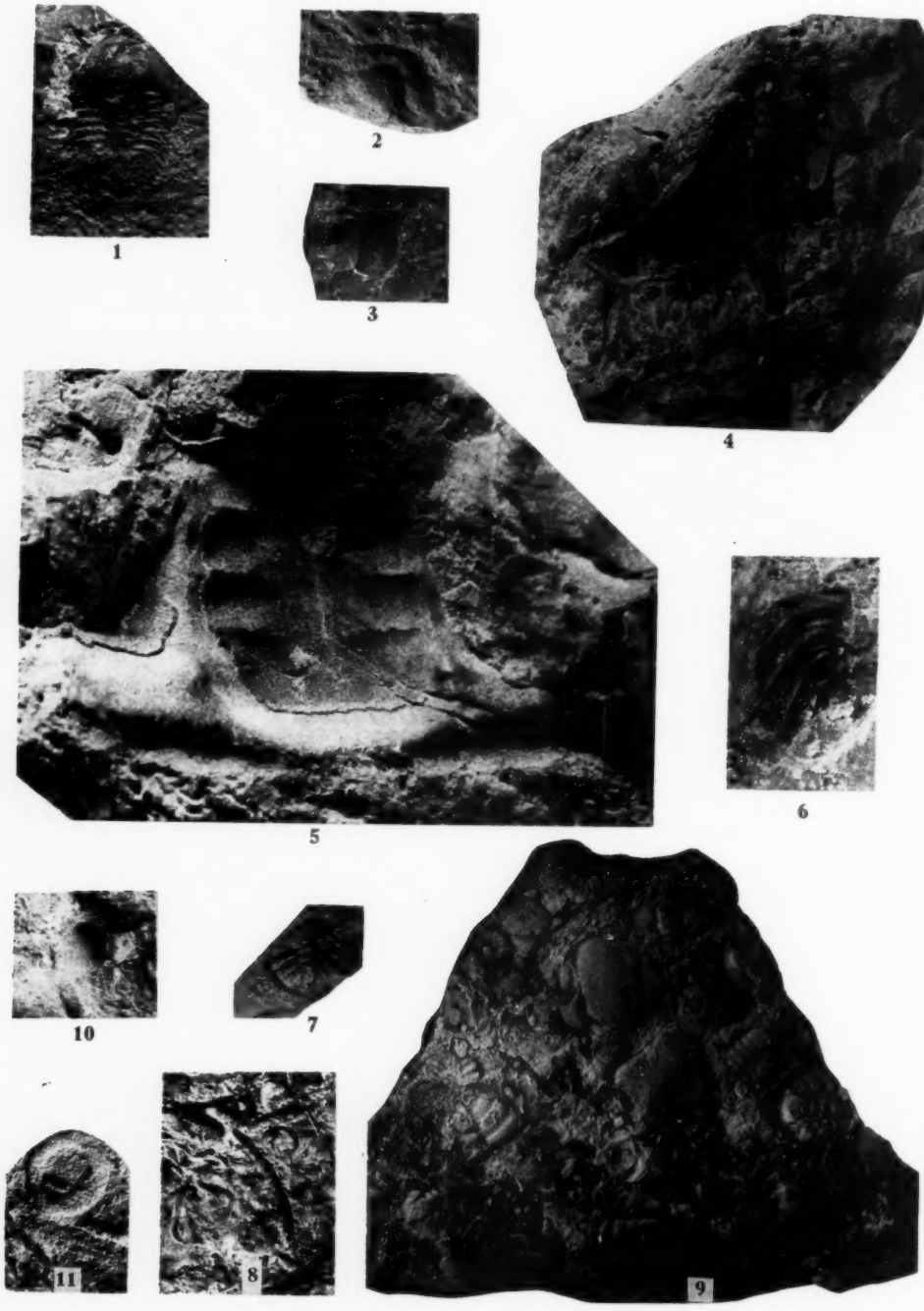
6–10—Glyphaspis atlantica Howell, n. sp. *6*, Paratype cranidium, Princeton 51048, ×4. *7*, Paratype free cheek, Princeton 50457, ×2. *8*, Holotype cranidium, Princeton 51043, ×2. *9*, Paratype cranidium, Princeton 51046, ×4. *10*, Paratype cranidium, side view, Princeton 51046, ×4. Middle Cambrian, Cloud Rapids formation. Canada Bay, Newfoundland. (p. 242)

11—Anomalocephalus? terranovicus Howell, n. sp. Holotype cranidium, Princeton 51103, ×2. Middle Cambrian, Cloud Rapids formation. Canada Bay, Newfoundland. (p. 242)

12–17—Solenopleura proavita Howell, n. sp. *12*, Holotype (specimen at upper left) and paratype tests, Princeton 51053, ×2. *13*, Paratype cranidium, Princeton 51059, ×3. *14* Paratype cranidium, side view, Princeton 50595, ×2. *15*, Paratype cranidium, Princeton 50654, ×2. *16*, Paratype young cranidium, Princeton 50591, ×3. *17*, Paratype young test, Princeton 51054, ×4. Middle Cambrian, Cloud Rapids formation. Cloud Rapids, Canada Bay, Newfoundland. (p. 243)



Howell, Cambrian Fossils from Newfoundland



Howell, Cambrian Fossils from Newfoundland

of southeastern Newfoundland (which contains an *Ehmania*-like species, *rogersi*, which has recently been made by Wheeler (1941) the genotype of a new genus, *Braintreella*) and the corresponding *Paradoxides harlani* fauna of eastern Massachusetts, which must be of somewhat the same age as the Pentagon formation of Montana, which overlies the Pagoda.

It is possible that the Cape Wood fauna of Northwest Greenland is of much the same age as the Cloud Rapids assemblage. A fauna similar to, but not identical with, the Cloud Rapids fauna, and as yet undescribed, was found by the writer in 1936 in one of the lower limestones of the March Point formation, on the St. George Peninsula, southwestern Newfoundland, stratigraphically below the late Medial Cambrian *Marjumia-Eldoradia* fauna described from that section by Lochman (1938).

The similarity of the Cloud Rapids fauna to that of the Wolsey, Damnation, and Pagoda formations of the Rocky Mountains is remarkable and makes possible a closer correlation of our Newfoundland fauna with western North American faunas than has usually been possible between Cambrian faunas of the Atlantic and Cordilleran regions.

No fauna resembling the Cloud Rapids fauna is known in northwestern Europe, and beds of the age of the Cloud Rapids and Treytown Pond formations are probably not present in that part of the world. Somewhat similar faunas are, however, known in eastern Asia; and the *Ehmania* faunas and related faunas may have had a wide distribution in the Arctic and Subarctic seas of their times.

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EXPLANATION OF PLATE 39

FIG. *1*—*Solenoparia? newfoundlandensis* Howell, n. sp. Holotype test, Princeton 51104, ×3. Middle Cambrian, Cloud Rapids formation. Long Arm, Canada Bay, Newfoundland. (p. 243)

2, 3—*Megagraulos? terranovicus* Howell, n. sp. *2*, Holotype cranidium, Princeton 51105, ×2. *3*, Paratype cranidium, Princeton 51106, ×4. Middle Cambrian, Cloud Rapids formation, Long Arm, Canada Bay, Newfoundland. (p. 244)

4–6—*Kootenia longispina* Howell, n. sp. *4*, Paratype pygidium, Princeton 51112, ×2. *5*, Holotype cranidium, Princeton 51112, ×4. *6*, Paratype pygidium, Princeton 51112, ×4. Middle Cambrian, Cloud Rapids formation. Cloud Rapids, Canada Bay, Newfoundland. (p. 244)

7–9—*Kootenia cloudensis* Howell, n. sp. *7*, Paratype pygidium, 51109, ×1. *8*, Paratype free cheek, Princeton 51115, ×2. *9*, Holotype (large cranidium in top center) and paratype cranidia and pygidia, Princeton 51107, ×1. Middle Cambrian, Cloud Rapids formation. Entrance to Little Treytown Pond, Canada Bay, Newfoundland. (p. 245)

10—Agnostian?, genus and species undetermined. Cephalon?, Princeton 51113, ×5. Middle Cambrian, Cloud Rapids formation, west of Barnes Cove, Canada Bay, Newfoundland. (p. 245)

11—Problematicum, Princeton 51117, ×2. Middle Cambrian, Cloud Rapids formation. West of Barnes Cove, Canada Bay, Newfoundland. (p. 246)

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CEPHALOPODS FROM THE SILURIAN OF ARISAIG, NOVA SCOTIA

ROUSSEAU H. FLOWER
University of Cincinnati, Cincinnati, Ohio

ABSTRACT—A boulder derived from the Stonehouse formation of Arisaig, Nova Scotia, has yielded four new cephalopods, two of which constitute the new genus *Paraphragmites*, which is homeomorphic with the mixochoanitic genus *Aphragmites* Barrande. The recognition of *Oxygonioceras* and *Hercocyrtoceras* in the formation strongly suggests that the Stonehouse beds are only slightly younger if at all than recognized American and European strata of Middle Silurian age.

INTRODUCTION

THE NEW cephalopods described in the following pages occurred in a loose boulder found on the shore between Arisaig, Nova Scotia, and Frenchman's barn, some distance southwest of Beechill Cove. In this region the coast is largely composed of igneous rock, though the Beechill and Ross Brook formations are present (McLearn, 1924, p. 2). Study of the associated fauna of the boulder, however, revealed an abundance of species commonly found only in the higher Stonehouse formation, so that it is necessary to conclude that it was originally derived from that horizon, which is exposed about two miles farther south on the coast. The material was collected by Dr. C. A. Hartnagle, who kindly offered the cephalopods to the writer for study. The boulder, derived from a band of shell limestone deposited among arenaceous gray sandy shales, is made up largely of small pelecypods and gastropods. The complete fauna of the boulder is as follows:

Chonetes novascotius Hall.
Nuculites cawdori (Sowerby).
Nuculites concentricus (Hall).
Nuculites concentricus var. *subovatus* (Hall).
Leda megumaensis McLearn.
Pteronitella curta Billings.
Plectonotus trilobatus (Sowerby).
Goniostrophia aciculata (Hall).
Holopea caecistriata? McLearn.
Tentaculites canadensis Ami.
Kionoceras angulatum (Wahlenberg).
Michelinoceras hartnaglei Flower, n. sp.
Oxygonioceras novascotium Flower, n. sp.
Paraphragmites ascoceroides Flower, n. sp.
Paraphragmites gomphoceroides Flower, n. sp.

Except for the *Holopea*, which is closest to a species known so far only from the Ross Brook formation, the species are those reported by McLearn (1924, pp. 15–18) as common only in the Stonehouse formation, though many of the species are rare but present in various of the underlying beds. In addition, it should be noted that the two species of *Paraphragmites* are almost certainly the same as the more fragmentary specimens that McLearn identified as *Dawsonoceras elegantulum* (Dawson) from the Stonehouse formation.

CEPHALOPODS PREVIOUSLY DESCRIBED FROM ARISAIG

McLearn (1924) recognized 16 species and varieties of cephalopods from the Silurian of Arisaig, Nova Scotia. Unfortunately at the time when this work was done the study of nautiloids had not yet reached its present precise condition, and most cephalopods were known only from those features presented by the exterior of the specimens. Indeed, at that time there was no good basis for making close comparisons with orthoceracones of the Silurian of either America or Europe. Although our knowledge of American Silurian orthoceracones has been greatly increased, largely by the careful investigations of Foerste, so little is still known of many of the European species with which those of Arisaig are probably comparable, judging by the affinities shown by the remainder of the fauna, that precise comparison is impossible, and there is even grave doubt as to the true generic position of

many of the described forms. Today a restudy of these species would necessitate not only the examination of the Arisaig material by sections but a similar treatment of many British and European species.

The species previously described are summarized here together with such comments as seem to be of particular value.

Orthoceras mcadamensis McLearn: This species, known only from the McAdam formation, is a moderate-sized slender orthoceracone with shallow camerae. The section is slightly depressed. The small siphuncle lies slightly ventrad of the center. In the absence of knowledge of the form of the siphuncle, generic identification is not possible.

Orthoceras ludense var. *camarini* McLearn: This form, from the Moydart formation, is regarded as a variety of *O. ludense* (Sowerby) from the Ludlow of England. The species has deep camerae and septa and a very large slightly eccentric siphuncle. It would appear that this species could be compared equally well with several known American forms, in particular, "*Orthoceras*" *alienum* Hall and *Harrisoceras rectum* (Hall). The strongly curved septa and large siphuncle suggest *Harrisoceras* as developed in the Silurian of east-central North America. Generic identification cannot be certain without more information as to the structure of the interior.

Orthoceras antigonishense McLearn: In the absence of information as to the internal structure, this species, of the lower part of the Stonehouse formation, is likewise of uncertain generic position. The form is a particularly slender one with rather shallow camerae.

Orthoceras punctostriatum McLearn: This is a small slender species of the Stonehouse formation superficially similar to *Michelinoceras hartnaglei* but differing in that the siphuncle is central rather than strongly eccentric. Again, the internal structure is not known, and the generic position is doubtful.

Orthoceras confertiseptatum McLearn: This species of the Moydart and Stonehouse formations is a moderately expanding form with very shallow camerae. The generic position is uncertain.

Orthoceras marklandense McLearn: A small slender species of the Stonehouse formation, of uncertain generic position. It is unlike any known American species. The septa are closer than in *M. hartnaglei*. Nothing is known of the internal structure.

Orthoceras bullatum var. *pictonense* McLearn: This common form of the Moydart is regarded as a variety of the Wenlock *O. bullatum* Sowerby. The fine longitudinal lines are considered characteristic of *Polygrammoceras* Foerste, a genus that ranges from Lower Ordovician to Lower Devonian.

Dawsonoceras elegantulum (Dawson): This species is reported by McLearn as abundant in the Stonehouse formation. However, the variation in proportions reported by McLearn suggests that more than one species was present. Possibly under this name were included fragments from the earlier part of the conch of *Paraphragmites ascoceroides*, *P. gomphoceroides*, and probably at least one additional species. Dawson's species cannot be recognized except by means of restudy of his types, which do not seem to be preserved.

Dawsonoceras arasaigense McLearn: This species of the McAdam formation has low annuli and transverse markings. Such surface features are common in the Silurian of Bohemia among species formerly referred to *Cycloceras*, but for which no new generic name has yet been proposed. Comparable species are not present in America.

Kionoceras angulatum (Wahlenberg): The Arisaig forms identified by McLearn with this species, described from the Silurian of Sweden but regarded as widespread in the European Silurian, occur in the Ross Brook formation and again in the Stonehouse formation. Dawson described this form as *O. exornatum*, but, as was common in those days, failed to compare his species with described forms from Europe. Though from what is known of the restricted range of cephalopod species this name may eventually be restored, it is refreshing to find that McLearn had the courage to reduce it to synonymy, where it may well remain until further study brings out better differences than are supplied by the extant published figures and descriptions of both the European and the Arisaig forms.

Kionoceras angulatum var. *deflectostriatum* McLearn: This is a Stonehouse form differing from the above in the presence of a clear sinus, probably the hyponomic sinus.

Kionoceras latouri McLearn: A typical *Kionoceras* from the Ross Brook formation, of rather generalized aspect.

Kionoceras granosistriatum McLearn: This species, believed to come from the Stonehouse formation, has low narrow ridges with wide interspaces, a type of ornament widespread in the Silurian of America and Europe. The fragment is not complete enough to show definite affinities with either geographical group of species.

Hercocyrtoceras erro (McLearn): This Stonehouse species is a small cyrtocone with distant annuli crossed by distant lirae. Where the two join linear nodes develop. There are finer transverse markings. The rapid expansion and the character of the ornament are not typical of *Casteroceras*, to which genus the writer (Flower, 1936, p. 50) tentatively assigned this species, but, instead, are typical of *Hercocyrtoceras*, previously known only from the genotype, of the Jupiter formation, Anticosti.

Cyrtorizoceras breviradiatum McLearn: This Stonehouse species is not closely allied to any American species. It is unlike *Cyrtorizoceras*, s. s., in the reduction of expansion at the adoral end of the phragmocone, and also in the rounded venter. It is related to a large complex of cyrtoconic cephalopods that characterize the Silurian of Europe and are particularly well developed in Bohemia. Such species seem to pass through the tenuous boundaries between *Oonoceras*, *Cyrtorizoceras*, *Oxygonioceras*, and even to *Rizoceras*, and thence to endogastric cephalopods. The vast number of species concerned and the gradations of form make it impossible to set up clear generic boundaries, and many species could be placed in either of two genera with seemingly equally good reason.

CORRELATION OF THE SILURIAN OF ARISAIG

The Silurian strata of Arisaig, Nova Scotia, have been divided into five formations, the Beechill, Ross Brook, McAdam, Moydart and Stonehouse, named in ascending order. McLearn (1924, p. 26) regarded these strata as embracing an interval extending nearly but not quite throughout the entire Silurian section. The Beechill formation he correlated with the lower Llandovery of Great Britain and the Medinan of America. The Ross Brook was regarded as the equivalent of the upper Llandovery and the lower Clinton. The McAdam and Moydart formations extend up to the Aymestry horizon of England and were regarded as the equivalent of strata in America now regarded as upper Clinton. The Stonehouse is correlated with the upper Ludlow of England and with the Louisville, Guelph, Salina and perhaps the lower Greenfield dolomite of the east-central region, at least with the later part of the Niagaran and the earlier part of the Cayugan. Incidentally, subsequent work has shown that the Louisville is Clinton in age and does not overlie the Lockport. In more modern terms, the section would be Racine, Guelph and Lower Cayugan.

In the recent correlation chart of the Silurian of America, Twenhofel (1942) extends both the British and the Arisaig sections much higher, so that the Arisaig section extends throughout the known Silurian. The Stonehouse formation is regarded as beginning in latest Niagaran time and extending throughout the Cayugan. In Europe its equivalents are the upper Wenlock, the entire Ludlovian, including the Aymestry formation and the lower Ludlow, and also the Downtonian. This treatment does not seem to be in accordance with the faunal evidence as presented by McLearn or with the additional information supplied by the new cephalopods described below.

The presence of *Hercocyrtoceras* in the Stonehouse formation, a genus known elsewhere only from the Jupiter formation of Clinton age, suggests a closer age approximation of the two formations than is indicated by either McLearn or Twenhofel. Equivalence is not implied and, indeed, is hardly possible, for the strongest faunal resemblances between the two sections are between the Ross Brook of Arisaig and the Jupiter of Anticosti. *Oxygonioceras* is not known above the Wenlock of England, above the Middle Silurian Étage 2 of Barrande in Bohemia, while in America it has not been recognized in strata younger than

the Clinton. Horizon E_2 of Bohemia contains many faunal types, however, which reach east-central North America only in post-Clinton time, Lockport in the broader sense. Likewise, *Cyrtorizoceras breviradiatum* McLearn, though of uncertain generic position as noted above, shows affinities with Bohemian species also from the Middle Silurian Étage 2. The cephalopods, insofar as they can be used for correlation at present, suggest that even McLearn's correlation of the Stonehouse formation may be rather high.

Much has been made of our lack of knowledge of typical marine associations of the Upper Silurian. However such strata are known in horizon F1 of Bohemia, and in the Cobleskill limestone of New York. The Cobleskill limestone contains a considerable though largely undescribed cephalopod fauna, which the writer has had opportunity to study, while a few cephalopods are also known from the Upper Silurian Étage F_1 of Bohemia. A few smooth orthoceracones and species of kionoceroid aspect persist into the Upper Silurian of both regions. Among the smooth forms actinoceroids are dominant, being represented by *Ormoceras* and *Armenoceras*. The phragmoceroids persist and are represented by *Gomphoceras*, s. s., *Hexameroceras*, and *Tetrameroceras*. An undescribed breviconic genus of peculiar aspect, to be described in a revision of the Cobleskill cephalopods, is common to both regions. Peculiar to the American section are *Pristeroceras* Ruedemann and the high-spired trochoceroids *Mitroceras* Hyatt and *Foersteoceras* Ruedemann. The cephalopods of the Stonehouse formation show no affinities with either of these faunas but, instead, retain types comparable to Middle Silurian cephalopods of Bohemia.

The faunal lists presented by McLearn show that many of the species of the Stonehouse formation appear much farther down in the Arisaig section. There are enough of these to suggest that the beds of Arisaig could hardly have embraced the entire Silurian. No species are common to the Lower Silurian Beechill and the Stonehouse, but those of the Ross Brook, McAdam, and Moydart recur in the overlying Stonehouse. Even with the elimination of the few ubiquitous and wide-ranging types such as *Atrypa reticularis*, the number of forms persisting throughout this part of the section is sufficient to suggest very strongly that the Stonehouse could hardly embrace the entire Upper Silurian. Indeed, such recurrence suggests strongly, as do the cyrtoconic cephalopods, that this fauna may not be much younger, if at all, than known Middle Silurian strata of Europe and America.

DESCRIPTION OF SPECIES

MICHELINOCERAS HARTNAGLEI Flower, n. sp.

Plate 40, figure 15

This is a small but highly characteristic *Michelinoceras*, very slender, slightly depressed in section, the type expanding from 11 by 12 mm. to 13 by 14 mm. in a length of 36 mm. The sutures are stright and transverse. The camerae are spaced four in a length equal to an adoral shell height adapically, and three and two-thirds camerae in a similar length adorally. The adoral increase in the depth of the camerae is slightly greater than the increase in the diameter of the shell. The septa are shallow, being 1.2 mm. at a shell height of 13 mm. and scarcely equal to half the depth of a camera. The siphuncle is close to the ventral wall, though well separated from it, unusually large, and composed of segments that may be nearly as broad as long. The septal necks are short but slightly recurved, the extent of curvature varying considerably from segment to segment. Adorally at a shell height of 13 mm. a segment is 2 mm. from the venter and 7 mm. from the dorsum, being 3 mm. in diameter within the camera, and 3.5 mm. in length. At the septal foramen the segment is 2.2 mm. in diameter. No organic deposits are found in the siphuncle, but mural deposits are well developed against the ventral side of the camerae, though no such deposits are found against the dorsal wall. The surface of the shell bears coarse rugose transverse markings, which indicate the presence of a shallow hyponomic sinus on the venter.

Discussion.—The large ventral siphuncle and the slender form, together with the exceptionally shallow curvature of the septa, set this species apart from all comparable forms. No closely similar species is known to the writer from the Paleozoic of Europe or

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Discussion.—The large ventral siphuncle and the slender form, together with the exceptionally shallow curvature of the septa, set this species apart from all comparable forms. No closely similar species is known to the writer from the Paleozoic of Europe or

America, though it is quite possible that restudy of the vast number of species that have been described as *Orthoceras* in the past may reveal some such form. American Silurian orthoconic cephalopods have been carefully restudied, and no similar species is among them. However there remains a large array of described European species that are still far too inadequately known for proper comparison. Yet none of these that have so far come to my attention present features strikingly similar to this Arasaig species.

Type.—Holotype, New York State Museum no. 12315k/1.

Occurrence.—From a loose boulder attributed to the Stonehouse formation, found on the beach about one-half mile northeast of Arasaig, Nova Scotia.

Genus OXYGONIOCERAS Foerste

FOERSTE, *1925*, Denison Univ. Bull., Sci. Lab. Jour., vol. 21, p. 62.
1926, Idem., vol. 21, p. 375, pl. 42, figs. 1A–E.
1929, Idem., vol. 24, p. 217.
1935, Idem., vol. 30, p. 43.

Genotype, *Trochoceras oxynotum* Barrande.

Conch strongly curved, slender, the shell becoming coiled in a loose dextral spire. The whorls are free or barely in contact; no impressed zone is ever developed. The section is strongly compressed, the dorsum rounded, the venter either very narrowly rounded or angulate. The sutures form broad lobes over the lateral portions. The siphuncle lies close to the venter. It is composed of broadly nummuloidal segments, subscalariform in vertical section, with the brim best developed dorsally, and the area of adanation best developed ventrally. The siphuncle is without any known organic deposits, as are the camerae. The surface of the shell is smooth or marked only with relatively faint transverse markings, which preserve the contour of the hyponomic sinus.

Discussion.—The species that agree with the genotype in being rather strongly compressed and in having the ventral side of the cross section definitely angular are few. However, they are connected with another group of species of somewhat broader whorl and less markedly angulate venter, which it seems better to place in this genus than to erect a new genus for their reception. Among these species are some having whorls in which the width is equal to or even greater than the height. Some show only faint traces of trochoceroid curvature, while the extant illustrations of a few of the species described by Barrande fail to show any conclusive evidence of eccentricity of coiling. Yet these species agree with the genotype of *Oxygonioceras* and differ from all other genera in the combination of two features: (1) the conch is strongly curved, and yet expands very slowly, so that even in the most gently curved species the conch must have described at least one volution when complete; (2) the ventral siphuncle is much more strongly expanded than in related cyrtoconic cephalopods.

It is apparent that the strongly compressed species of *Oxygonioceras* are specialized types, and the broad-whorled species are more generalized. In fact, such species serve to point out a relationship between *Oxygonioceras* and simpler cyrtoconic cephalopods. Elsewhere (Flower, 1942, pp. 24–31) the writer has pointed out the relationships that are believed to have existed among the various Ordovician cyrtoconic genera. Inasmuch as the genera themselves are based upon form more than on internal structure, such relationship is probably synthetic. What is known of the internal structure of the species involved in *Beloitoceras*, to cite only one example, suggests that the true relationship may be much more complex.

The oldest known radicles of the compressed cyrtocones, barring Canadian species, which appear to have quite different siphuncular structure, are those constituting the genus *Beloitoceras* of the Oncoceratidae. In Middle Ordovician time compressed cyrtocones lacking the apertural contraction developed. These species are retained in the genus *Richardsonoceras* Foerste. More slender compressed forms with more crowded septa and more slender siphuncles make their appearance in boreal faunas of late Trenton to Richmond age and continue on into Middle Silurian time, where the genus becomes prolific and the species more variable.

Cyrtorizoceras made its appearance in the Ordovician of America and arose from the same general stock. It is characterized

mainly by the more rapid vertical expansion of the shell. It is better known in the American Silurian, and there are also many species of *Cyrtoceras* in the Silurian of Bohemia that appear to be typical members of the genus. The range of the species suggests, however, that *Cyrtorizoceras* may be a form genus, and that Ordovician and Silurian species may not be closely related. The genus is not yet known from strata of demonstrable Upper Ordovician age. There is clearly a stratigraphic interval in which the genus is unknown. The Silurian species grade into those of the more slender genus *Oonoceras* to such an extent that there is considerable doubt as to where the boundary should be drawn between the two genera. This is shown clearly by the described species from the Middle Silurian of Bohemia. Not only is there gradation in form, but the species that appear to intergrade on the basis of external features are also for the most part those that possess siphuncles broader than typical for *Oonoceras* and approaching the condition found in "typical" Silurian *Cyrtorizoceras*, which may eventually prove not to be typical at all when more is learned of the structure of the Ordovician genotype.

Oxygonioceras clearly sprang from some point in the prolific development of cyrtoconic cephalopods in the Silurian. The broad segments of the siphuncle are more similar to those of Silurian *Cyrtorizoceras* than to other contemporaneous forms. The genus might be interpreted as a development out of *Cyrtorizoceras* characterized by a decrease in the rate of expansion and an increase in coiling, so that a loose low faintly eccentric spire was developed.

The possibility that the stock of *Oxygonioceras* may be relatively long lived is suggested by the superficially similar genus *Digenuoceras* Foerste (1935, p. 43) of the Big Horn formation and the Red River formation, Upper? Ordovician. That genus is strongly compressed but apparently cyrtoconic, but the dorsal outline as well as the ventral outline is angular. A more significant difference is to be found in that the siphuncular segments of *Digenuoceras* are reported as relatively slender, while in *Oxygonioceras* they are uniformly very broadly expanded. Probably the resemblance between the genera is homeomorphic, a conclusion that is strengthened by the apparent gradation of form between *Oxygonioceras* and *Cyrtorizoceras* on the basis of known Bohemian species.

Oxygonioceras is known from the Middle Silurian of Bohemia, where it is best developed. American species include *O. novascotium* described below, from the Stonehouse formation of the Silurian of Arasaig, Nova Scotia, *O. wabashense* Foerste, from the Liston Creek limestone of northern Indiana, of Clinton age; and *O. cuneatum* (Whiteaves), from the Stonewall formation of Manitoba, which embraces an interval ranging from Clinton probably into the Lockport horizon. The exact position of the bed that yielded *Oxygonioceras* is not known. The Bohemian species are *O. oxynotum* (Barrande), *O. postulatum* (Barrande), *O. priscum* (Barrande), *O. speciosum* (Barrande), and *O. simplex* (Barrande). All of these species have angulate venters.

The following species are broader, and more or less atypical:

Oxygonioceras anguis (Barrande) lacks the angulation of the venter.

O. clava (Barrande) has a markedly contracted mature living chamber, a feature only slightly developed in most other species.

O. aequale (Barrande) is similar in form to *O. clava*.

O. minus (Barrande) is typical in section and sutures but is a small species which may be only cyrtoconic.

O. regale (Barrande) is atypical in section, being broader than high, and having the venter slightly flattened. In form and internal structure it is typical and must be placed here unless a new genus is to be erected for its reception.

O. crassius (Barrande) is similar in section to *O. regale*.

The only additional species from Europe which has thus far come to my attention is *O. tortuosum* (Sowerby), of the Wenlock shale of the Silurian of England.

Oxygonioceras novascotium Flower, n. sp., described below, is closer to *O. priscum* than to any other species, but is considerably larger, and shows the faint contraction of the living chamber of *O. clava*. It is not strikingly similar to any of the previously known

American species, which are very strongly compressed and more slender. This is to be expected from the European affinities shown by other elements of the faunas of the Silurian of Arasaig.

OXYGONIOCERAS NOVASCOTIUM Flower, n. sp.
Plate 40, figures 12–14

This species is represented only by the holotype, which consists of a little less than half a volution, with a maximum diameter of 145 mm. Curvature is very faintly dextral and the complete shell must have had a very loosely coiled low spire with the whorls free or barely in contact. The section is compressed, the venter subangulate, the dorsum rounded. The radius of curvature of the venter increases very gradually from 75 mm. near the base of the type to 90 mm. near the aperture. At the base of the specimen the whorl is 25 mm. high and 23 mm. wide. In a ventral length of 170 mm. along the phragmocone, the height increases to 42 mm. and the width to 38 mm. At the aperture, in a ventral length of 45 mm., the width becomes 43 mm. and the height 45 mm. There is a slight vertical contraction of the shell as the aperture is approached.

The sutures describe broad shallow lateral lobes and slope slightly orad from dorsum to venter. The camerae are shallow, nine occurring in a length equal to an adoral shell height of 41 mm. The last few camerae are slightly shallower, indicating the approach of maturity.

The siphuncle lies close to the venter and is formed of short broad segments typical of the genus. No trace of deposits can be seen in either the siphuncle or the camerae.

The surface is marked by transverse lines of growth, which thicken at irregular intervals. The lines curve apicad over the venter, forming a shallow hyponomic sinus. In addition, the surface bears fainter longitudinal markings, best seen on the dorsal surface. These are always very obscure.

Discussion.—As noted under the discussion of the genus, this species is less strongly compressed than either of the two specimens previously recorded from the American Silurian, and appears to be closest to *Oxygonioceras priscum* Barrande, of the Middle Silurian of Bohemia. However *O. novascotium* shows a faint adoral vertical contraction of the shell, better developed in *O. clava*, and it is a very loosely coiled form in which the trochoceroid condition is barely apparent in the known portion of the shell.

Type.—Holotype, New York State Museum, no. 12438t/1.

Occurrence.—From a boulder derived from the Stonehouse formation, on the coast northeast of Arisaig, Nova Scotia.

Genus PARAPHRAGMITES Flower, n. gen.

Genotype, *Paraphragmites ascoceroides* Flower, n. sp.

This genus is erected for species that bear a remarkable superficial resemblance to annulated Ascoceratidae, in particular the genus *Aphragmites* Barrande, although neither the sutures, septa nor the siphuncle show any relationship between this genus and any of the Mixochoanites. The conch is annulated throughout except for a narrow zone next to the mature aperture. The surface bears in addition fine transverse lirae and striae, with fainter longitudinal markings. The early portion of the shell is slender, faintly curved exogastrically. The septa are shallow and evenly curved. The sutures are straight and transverse. The siphuncle lies

EXPLANATION OF PLATE 40

FIGS. *1–3, 11—Paraphragmites ascoceroides* Flower, n. sp., Holotype, ×1: *1*, Ventral; *2*, lateral; *3*, dorsal views. *11*, Lateral view of paratype, ×1. (p. 255)

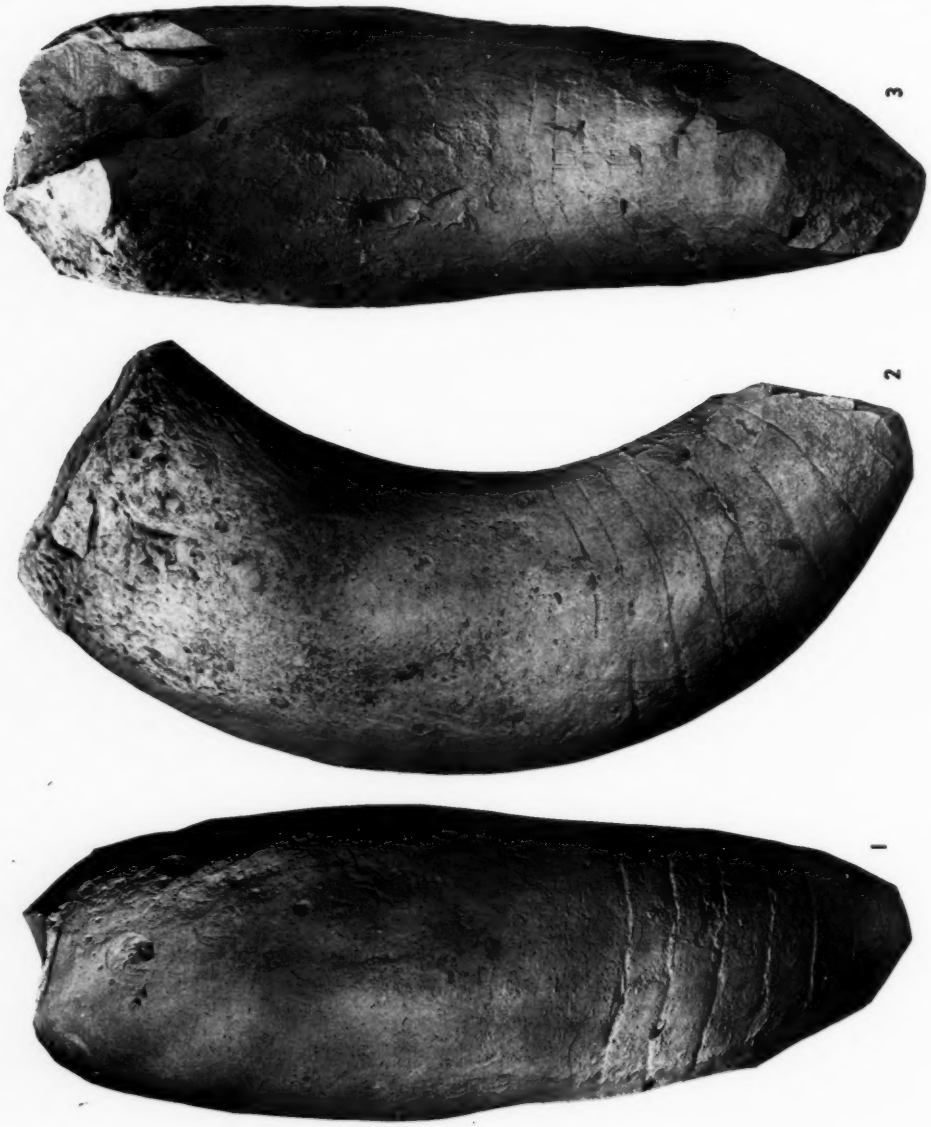
4–10—Paraphragmites gomphoceroides Flower, n. sp. Holotype, ×1: *4*, Lateral; *5*, ventral views. Paratype: *6*, septal view, ×1; *7*, vertical section through adapical part of phragmocone, ×2; *8*, ventral; *9*, lateral; *10*, dorsal views, ×1, of adoral portion of conch. (p. 256)

12–14—Oxygenioceras novascotium Flower, n. sp. Holotype: *12*, Ventral aspect, ×⅔; *13*, lateral aspect, ×⅔; *14*, septum at base of specimen, ×1 (p. 254)

15—Michelinoceras hartnaglei Flower, n. sp. Holotype, sagittal section, ×1.

All specimens are from a boulder from the Stonehouse formation on the coast northeast of Arisaig, Nova Scotia. All are deposited in the New York State Museum. (p. 251)

Flower, Silurian Cephalopods from Nova Scotia



Flower, Trenton *Apsidoceras* at Montreal

slightly dorsad of the center and is composed of cyrtochoanitic broadly expanded segments subcircular in section. No organic deposits are known in either the camerae or the siphuncle. Although the aperture has not been completely observed, the condition of the surface features indicates that no hyponomic sinus was developed.

Discussion.—The name given to this genus is based upon its remarkable but apparently entirely superficial resemblance to the ascoceroid genus *Aphragmites* Barrande. Indeed, when first found, the specimens were believed to belong to *Aphragmites*, as that genus was first described from specimens lacking the mature ascoceroid septa. Even specimens of that genus lacking the characteristic septa of the ascoceroid can be distinguished from *Paraphragmites* by a number of secondary features. *Aphragmites* is compressed in section; this form is circular or slightly depressed. In *Aphragmites* the septum of truncation at the base of the mature part of the shell is asymmetrically curved in a vertical plane, curvature being greatest on the ventral side. The greatest depth of the septum lies well ventrad of the center of the section, and the siphuncle is located there. In *Paraphragmites* the septum is curved symmetrically, and the siphuncle lies slightly dorsad of the center. The siphuncle of *Aphragmites*, and all known ascoceroids is planoconvex in form in the early stages. In *Paraphragmites* the siphuncle is made up of broad biconvex segments. Differences are also found in the form of the living chamber. *Aphragmites* is more gibbous basally, and the produced neck is sinuate, being curved first dorsad and then ventrad before the mature aperture is attained. In *Paraphragmites* the exogastric curvature is evident throughout, and the ventral wall of the neck does not become concave at any point. These differences will be found useful for comparison with immature *Aphragmites* lacking the ascorceroid septa. It has been found that the asymmetrical vertical curvature of the septum is characteristic of even the earliest of the mixochoanitic cephalopods, and as it is retained in the earlier stages of the most specialized forms it supplies one of the most convenient criteria of the group.

PARAPHRAGMITES ASCOCEROIDES Flower n. sp.

Plate 40, figures 1–3, 11

The mature living chamber of this species is subcircular in section, the width scarcely greater than the height, slightly curved, slightly inflated over the basal portion, contracting slowly to the aperture, with the rate of contraction gradually decreasing orad so that the aperture is essentially tubular. The living chamber is 42 mm. long and 11 mm. in diameter basally. In the basal 15 mm. the diameter increases to 14 mm. and contracts to 9 mm. at the aperture. The plane of the aperture and the plane of the last septum are slightly inclined, as both are normal to the axis of the slightly curving conch. The suture at the base of the living chamber is straight and transverse to the shell axis. The septum is evenly curved, shallow, 1.2 mm. in depth. The siphuncle is 1 mm. in diameter at the septal foramen, and is 0.5 mm. nearer the dorsum than the venter.

The internal mold of the living chamber bears annuli, which are nearly normal to the shell axis but curve slightly forward from the dorsum to the venter. The annuli are narrowly rounded and are separated by broad interspaces, which are faintly concave adapically but adorally become deeper. The constriction between the last two annuli is particularly deep. Farther orad, the annuli disappear, and are succeeded by a smooth area 10 mm. long before the aperture is reached. The shell surface bears fine, rather irregularly spaced transverse lirae, which cross the annuli. In addition, there are fainter closely spaced longitudinal markings.

A paratype representing an earlier part of the phragmocone of this species expands

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EXPLANATION OF PLATE 41

FIGS. *1–3*—*Apsidoceras montrealense* Flower, n. sp. *1*, Ventral; *2*, lateral; *3*, dorsal views of holotype about ×6/7. Trenton limestone, Isle Jesus, Quebec. (p. 258)

from 6 mm. to 9 mm. in a length of 27 mm. Seven annuli are found in this length. The camerae appear to agree with the annuli in spacing, each suture occurring in an interspace.

Discussion.—In form this species, rather more than the associated *Paraphragmites pupa*, resembles ascoceroids of the genera *Lindstromoceras* Miller and *Aphragmites* Barrande. If internal structures are ignored, this form may be considered a much attenuated edition of *Lindstromoceras cochleatum* (Lindstrom) (see Miller, 1932, pl. 5). However, as pointed out in the generic discussion, the features of the phragmocone serve to distinguish *Paraphragmites* from all Ascoceratidae, as the ascoceroid septa are absent, the section is not compressed, the form of the septa prior to the development of the ascoceroid septa is very different and the siphuncles vary widely in structure.

Mclearn (1924, p. 156, pl. 24, figs. 1–3) probably included immature fragments of this species under the name *Dawsonoceras elegantulum* (Dawson), but also included under that name fragments that cannot be regarded as conspecific either with this or the following species, as the original of Mclearn, 1924, pl. 29, fig. 7. Dawson's original description, which Mclearn quotes with the addition of a revised description calling attention to variation in the species, is so general that it leaves uncertainty as to whether his original specimens were conspecific with this form, the following one, or whether a third species is involved. The matter can only be settled by an investigation of the types, which do not seem to be extant.

Types.—Holotype, and paratype, New York State Museum, no. 12439k/1-2.

Occurrence.—From a loose boulder attributed to the Stonehouse formation of the Silurian of Arasaig, Nova Scotia, found on the beach about one-half mile northeast of Arasaig, Nova Scotia.

PARAPHRAGMITES GOMPHOCEROIDES Flower, n. sp.

Plate 40, figures 4–10

This species is smaller than *Paraphragmites ascoceroides* and considerably different in form. The apical portion of the shell is straighter, so that the dorsum is not concave adapically and is only curved near the aperture, where it becomes slightly convex. The shell expands moderately, becomes gibbous owing to increased curvature of the venter, and contracts to the aperture. The holotype expands from 6 by 5.5 mm. at the base, where the section is faintly depressed, to 12 by 12 mm. at the base of the mature living chamber, in a length of 28 mm. The conch then contracts to 8 by 7 mm. at the adoral end of the living chamber, which probably does not quite attain the aperture. The living chamber is 12 mm. long, and its base lies just orad of the point of greatest diameter.

The sutures are straight and essentially transverse. The siphuncle is slightly dorsad of the center. The segments are subspherical, 2 mm. long, 2 mm. wide, but 1 mm. in diameter at the septal foramen. The septal necks are short and recurved. The camerae are spaced equally with the annuli except at the base of the living chamber, where two gerontic camerae in the holotype occupy a length of 1.4 mm. Annuli extend over the shell to the base of the living chamber, which is largely smooth, and recur near the aperture, where only one annulation is present on the holotype, though three are present over a slightly broader area on the paratype, indicating variability in this feature. The annuli are low and rounded and are not markedly narrower than the interpsaces as in *P. ascoceroides*. The surface markings consist of transverse lirae, which are separated by wider and more prominent interspaces than those of *P. ascoceroides*. Also, this species shows no trace of the longitudinal surface markings noted in that species.

The paratype, which supplied the information concerning the internal structure, is slightly smaller than the holotype. The living chamber is 11 mm. long, bears three annuli on the adoral half, and is contracted at the aperture to 8 by 7 mm.

Discussion.—This species may be distinguished from *P. ascoceroides* by the character of the surface ornamentation, the smaller size, and the different relations of the region of greatest diameter to the base of the mature living chamber. The rather different

proportions causes this species to show a much less marked resemblance to an annulated ascoceroid conch.

Types.—Holotype and paratype, New York State Museum, no. 12439o/1-2.

Occurrence.—From a loose boulder attributed to the Stonehouse formation of the Silurian of Arasaig, Nova Scotia, found on the beach about one-half mile northeast of Arasaig, Nova Scotia.

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APSIDOCERAS IN THE TRENTON OF MONTREAL

ROUSSEAU H. FLOWER
University of Cincinnati, Cincinnati, Ohio

ABSTRACT—*Apsidoceras*, formerly regarded as a Richmond genus, is represented in the Trenton of Montreal by a new species, *A. montrealense*, which differs from all other species rather markedly in certain features, which may perhaps be primitive. Other species of *Apsidoceras* are briefly reviewed. The family Apsidoceratidae, as here revised, contains the genera *Apsidoceras*, *Wilsonoceras*, *Characteroceras*, *Characterocerina*, *Deckeroceras*, and, doubtfully, *Fremontoceras*.

INTRODUCTION

A WIDE BELT of Ordovician strata, presumably representing deposits in one vast embayment from the Arctic, is represented by the Cape Calhoun series of Greenland, various localities in the Arctic Archipelago, the Ordovician rocks of Hudson Bay, the Red River series of Lake Timiskaming, the Whitehead formation of Gaspé, the Big Horn dolomite of Wyoming, and the Fremont limestone of Colorado. These beds carry a fauna that has been variously regarded as Trenton and Richmond in age. The preponderance of certain "advanced" types not known in the Trenton has been largely responsible for the rather prevalent opinion that these strata must be younger than Middle Ordovician. They show affinities in some respects with the fauna of the typical Richmond and, more strikingly, with the Richmond of Anticosti and the Maquoketa shale of the upper Mississippi Valley. The suggestion has also been put forward that in this vast embayment there are strata ranging from late Trenton age through Covington and into Richmond time, but that the absence of austral elements in the fauna has made it impossible to recognize Covington elements. This explanation has been rejected, perhaps too summarily, on the grounds that the strata were not thick enough, and that no good diastemic breaks suggestive of long periods of nondeposition could be detected.

The Trenton age of the strata has been adjudged by Kay (1935) and by Teichert (1937). Cephalopods are conspicuous in the fauna of the Arctic embayment, and a number of the characteristic genera have come to be regarded as indices of the Richmond. Kay found several of these supposedly Richmond genera of cephalopods in the Stewartville dolomite of the upper Mississippi Valley. The writer (Flower, 1942) has recently found a few additional cephalopod genera, formerly known only from the boreal faunas, in the Cynthiana limestone (Trenton) of Kentucky. Teichert (1937, p. 20) noted that only three of the cephalopod genera of the Cape Calhoun strata of northern Greenland were not yet known from strata of well-established Trenton age. These are *Apsidoceras*, *Huronia* and *Danoceras*. The species, *Apsidoceras montrealense* Flower, n. sp., described in the following pages, reduces this list to two genera. The type was kindly loaned to the writer for study by Mr. G. Winston Sinclair.

The new species is of particular interest in that it shows features by which it is set well apart from the previously described forms, and it is quite possible that these characteristics may be primitive. If so, it is the only example yet described of cephalopod types characteristic of the Trenton-Richmond Arctic assemblage in which a species in the Trenton has shown features that set it at all clearly apart from its relatives. Opportunity is taken here also to redefine the family Apsidoceratidae and to summarize the few genera that can properly be placed in it.

DESCRIPTION

APSIDOCERAS MONTREALENSE
Flower, n. sp.
Plate 41, figures 1–3

Conch curved, probably gyroconic when complete. The extant portion, with a ventral

length of 172 mm., an actual length of 142 mm., is cyrtoconic and consists of a mature living chamber and seven and a half camerae. The radius of curvature of the venter increases from 78 to 110 mm. in the length of the specimen. The section is faintly compressed, subtriangular, the dorsum rounded, the ventral face flattened, the sides curved and diverging ventrad. Expansion of the shell is uniform and moderate until a point is reached near the middle of the mature living chamber. From there the conch contracts slightly laterally, and the venter becomes slightly more convex in cross section toward the aperture. The height at the base of the specimen is 36 mm., where the width is not known owing to the weathering of one lateral surface. Slightly farther orad, the height is 41 mm. and the width 36 mm. The living chamber increases from 44 mm. high by 38 mm. wide to 46 by 44 mm. at midlength, to 48 by 41 mm. at the aperture. The ventral length of the living chamber is 98 mm.

The sutures are transverse and lobed. Lateral lobes occupy the entire lateral surface, are broad and rounded, and convex apicad. The lobes are shallow basally and more prominent adorally. The suture is nearly transverse on the ventral surface, the usual lobes being hardly apparent. A broad saddle separating the ventral lobes occupies the dorsum. The camerae decrease in depth adorally, a gerontic phenomenon noticeable in some other species of the genus over a longer interval of the phragmocone than in most cephalopods. The basal four camerae are subequal in depth, averaging 10 mm., the next three are successively shorter, the last having a ventral length of 7 mm. The siphuncle is not known. In the light of other Trenton species under similar conditions of preservation, it is extremely improbable that the siphuncle and even the free part of the septa are preserved, and sectioning was not attempted.

The dorsal surface of the internal mold bears two series of ridges, which are apparent only on the phragmocone and are found at the adoral end of each camera. They fade out before attaining the apical end of the camera wall. These are similar to the single septal furrow on the dorsal wall of most nautiloids.

The aperture is incomplete. There is faint indication of a broad and shallow hyponomic sinus. The surface features of the shell are not shown.

Discussion.—The adoral contraction of the camerae and the slight gibbosity of the living chamber are indices of maturity. Not infrequently in *Apsidoceras* both phenomena occur over a much longer interval of the shell than in other genera, and the adoral contraction may be observed on specimens which do not retain the living chamber but only the phragmocone. The adoral compression of the shell of the holotype is slightly exaggerated by compression, which has also tended to obscure the ventral face and has caused it to assume a slightly oblique position near the aperture. However, distortion is evidently slight, and this species is clearly more compressed than most of the known species of *Apsidoceras*, the possible exception being *A. magnificum altum* Foerste of the Ellis Bay formation of Anticosti.

Type.—Holotype, collection of Mr. G. Winston Sinclair, Sir George Williams College, Montreal.

Occurrence.—From the upper Trenton limestone, Isle Jesus, south of Terrebonne and north of Montreal, Quebec.

COMPARISON OF SPECIES

Though *A. montrealense* is clearly typical of *Apsidoceras*, it does not agree very closely in details of proportion or sutures with any other known species. It differs from all described forms in the more compressed section and the transverse sutures on the ventral face. This condition is approached by some other species, notably *A. elegans*, but not attained. Further, many of the species described here show a section that is definitely transverse, and in which the lateral lobes are reduced and occasionally wanting, while the ventral lobe is much better developed. The essential features of the described American species are summarized below:

Apsidoceras boreale Foerste and Savage (1927, p. 60, pl. 14, fig. 1A–C), of the Shamattawa limestone of Hudson Bay, is a smaller form, broader in section. It is known only from a portion of a phragmocone which

contracts laterally orad. The sutures describe broad ventral lobes but are essentially straight laterally.

Apsidoceras depressum Cooper (1930, p. 286, pl. 3, fig. 11–14), of the Whitehead formation of Gaspé, is very strongly depressed in section, has well developed dorsal as well as ventral lobes, but no lateral lobes. This species is unique in that the ventral surface, which is faintly convex at the center, becomes faintly concave laterally and then convex as it passes over the rounded lateral borders.

Apsidoceras elegans Troedsson (1926, p. 38, pl. 13, figs. 2, 3; pl. 14, figs. 2, 3; pl. 15; pl. 16), of the Cape Calhoun series of northern Greenland, is relatively close to *A. montrealense* in the relatively narrow section and also in the possession of lateral lobes. The ventral lobe, however, is well defined and not vestigial, and the section is not higher than wide.

Apsidoceras magnificum (Billings) (Foerste, 1928, pl. 8, figs. 1, 2, pl. 9, fig. 6), of the Vaureal formation of Anticosti, is more strongly curved than *A. montrealense*. The section is broad, the dorsum semicircular in cross section, the venter flat. Ventral lobes are developed, but not lateral lobes.

Apsidoceras magnificum altum Foerste (1927, p. 282, pl. 39, fig. 1), of the Ellis Bay formation of Anticosti, is a large species known from a very slightly curved fragment. The section is as high as wide, but lateral lobes are not developed. The extent of flattening and the condition of the ventral lobes of the suture are not clear from Foerste's figure and description. The conch fails to expand adorally, though the type consists only of a phragmocone.

Apsidoceras magnificum major Foerste (1927, p. 281, pl. 36, figs. 3, 4; pl. 38, figs. 3, 4), of the English Head formation of Anticosti, is broader than *A. montrealense* but agrees with it in well-defined lateral lobes but has lateral lobes that are even stronger. The conch becomes tubular, failing to expand over the adoral end of the phragmocone.

Apsidoceras magnificum multicameratum Foerste (1927, p. 283, pl. 39, fig. 2), of the Ellis Bay formation of Anticosti, has both ventral and lateral lobes well developed. The section is still broadly depressed, and the phragmocone contracts slowly orad while the camerae become increasingly deeper.

Apsidoceras sp. Foerste (1936, p. 379, pl. 56, fig. 8) is a fragment of a phragmocone from the Whitehead formation of Gaspé. It is remarkable for the unusual depth of the ventral lobe. The section of this form is probably very broad, but the specimen is too incomplete to permit a very close comparison with other species.

Strand (1934, p. 26, pl. 7, fig. 4) has described *Apsidoceras magnificum norwegicum* from the *Trinucleus* limestone of the Oslo area, which is fairly close to the Anticosti forms with which he considers it to be allied.

The above survey of the known species of *Apsidoceras* shows that most forms differ from *A. montrealense* in the broader section, the strong development of ventral lobes, and the less strongly developed lateral lobes, which may indeed be absent in some species. Further, many species become almost cylindrical in the later part of the phragmocone, while others may contract adorally. Such gerontic phenomena are only slightly developed in *A. montrealense* and are confined to the later half of the mature living chamber. This suggests that species in which the contraction is more widespread and appears earlier may be phylogerontic.

Consideration of the essential features and stratigraphic position of the species outlined above brings out in support of this view some facts that may be significant. The two species that are closest to the new Trenton form described above are apparently among the older ones. *A. elegans* of the Cape Calhoun series is of doubtful age, but its similarity to *A. montrealense* correlates well with Teichert's suspicion (1937) that the formation may be as old as the Trenton. The most closely similar of the Anticosti species is the oldest, *A. magnificum major*, the only species of *Apsidoceras* found in the English Head formation. Neither of these species show the shell contracting over the adoral end of the phragmocone.

Obviously more specialized and marked by a strongly depressed section, absence of lateral lobes, and the early appearance of

phylogerontic features are *A. boreale* of the Shamattawa limestone, *A. magnificum multicameratum* of the Ellis Bay formation of Anticosti, and *A. depressum* of the Whitehead formation of Gaspé. It is perhaps significant that the Anticosti species in this group occurs high in the column, while the other two species, from dolomitic facies, occur in associations that are perhaps more convincingly Richmondian than some others of the Arctic embayment. Probably *A. magnificum*, s. s., represents a slightly more primitive radicle of this same group of species. It is depressed and lacks lateral lobes but fails to show as early a contraction of the shell. The last, *A. magnificum altum*, is not fully enough described to fit into the sequence. As its phragmocone is essentially a curved tube, failing to expand adorally, it may also possibly be classed as a phylogerontic form.

In view of experience with other Arctic nautiloid genera that were once regarded as diagnostically Richmondian but have subsequently appeared in the Trenton, the correlation here between the determined and suspected age of the species and their form and structure is remarkable. In other genera thus far studied closely the Trenton species have failed to show features that can be demonstrated to be primitive.

The origin of *Apsidoceras* is obscure. The stratigraphic changes in section and sutures make it reasonably certain that the ancestral form was a relatively compressed conch, perhaps actually higher than broad in the whorl, with fairly well developed lateral lobes, but with the ventral lobes poorly developed or absent and the ventral face poorly defined. The siphuncle of *Apsidoceras* is slightly ventrad of the center, slightly expanding, but neither marginal in position nor very broadly expanded in outline. That prophecy is unsafe in paleontology is shown by the fact that no form is known which fulfills these requirements. Two equally likely, yet remote and unsatisfactory candidates are found in *Richardsonoceras* Foerste and *Paquetteoceras* Foerste. Both are unsatisfactory because their sections are narrowed and subangular ventrally. *Richardsonoceras* has a cyrtoconic siphuncle, which lies close to the venter, while *Paquetteoceras* has a subcentral orthochoanitic siphuncle. If either of these represents the ancestral stock of *Apsidoceras*, which seems doubtful, there is a considerable gap not bridged by any known species.

REVISION OF THE APSIDOCERATIDAE

Hyatt (1884) proposed the family Apsidoceratidae but later apparently thought better of it, for he subsequently (1900) removed it from circulation. In its original form it contained a series of genera which seem today to be a most peculiar combination. Hyatt included in it the Devonian actinosiphonate genus *Tripleuroceras*, the Ordovician *Apsidoceras*, which is cyrtochoanitic but not actinosiphonate, and three much younger coiled orthochoanitic genera, *Titanoceras*, *Ephippioceras*, and the little known *Pteronautilus*. In 1900 Hyatt placed *Tripleuroceras* in the Jovellaniidae, *Ephippioceras* in the Trigonoceratidae, but did not include either *Titanoceras* or *Apsidoceras* in his classification.

The family name Apsidoceratidae was revived by Troedsson (1926, p. 37) for orthochoanitic genera referred to the Trocholitidae, since Foerste had stated that *Trocholites* was holochoanitic. This view, which Foerste later abandoned, is incorrect. The definition of the Apsidoceratidae supplied by Troedsson is likewise invalid, since *Apsidoceras* itself is cyrtochoanitic. Nevertheless, Troedsson was correct in placing in this family two closely related genera, *Apsidoceras* and *Charactoceras*.

The family Apsidoceratidae is redefined as follows: Conch curved or coiled, shell surface relatively smooth, with transverse markings and sometimes lateral costae. A hyponomic sinus is always developed. The section is primitively triangular, the dorsum rounded, the venter flattened. Lateral lobes are present in primitive forms but are lost in specialized forms where the section is relatively broad and where a lobe occupies the broad ventral face. The siphuncle is cyrtochoanitic, with variably expanded segments, and is variable in position but never close to either the dorsal or ventral faces. No deposits have been found within the siphuncle. At the present time, the family is known only from the Middle

and Upper Ordovician and seems to have been typically developed in the boreal faunas. The genera and species are summarized as follows:

Apsidoceras Hyatt (1884). Conch curved or loosely coiled, the whorls always free. Section subtriangular, the dorsum rounded, the venter flattened, sometimes semicircular. The sutures have lateral lobes primitively, but the ventral lobe is weak or wanting. More specialized forms have a strongly developed ventral lobe, and the lateral lobes may be reduced or lost. The siphuncle is cyrtochoanitic, but the segments are relatively slender. It is located slightly ventrad of the center of the shell. Supposedly phylogerontic species contract gradually orad over a considerable part of the shell. The species have already been listed together with their more salient features.

Wilsonoceras Foerste (1929, p. 180). Conch coiled, section subcircular but retaining the ventral lobes of the sutures of *Apsidoceras*. Siphuncle broadly cyrtochoanitic, located slightly dorsad of the center. Species: *W. bighornense* Miller, *W. brevicameratum* Foerste, Big Horn formation of Wyoming; *W. mccharlesi* (Whiteaves), genotype, from the Red River series of Manitoba; *W. squawcreekense* Miller, Big Horn formation, Wyoming.

Charactoceras Foerste (1924, p. 234). This genus retains the broad whorl and the flattened venter together with the ventral lobes of the more specialized species of *Apsidoceras*. The conch is closely coiled. The siphuncle is cyrtochoanitic, ventrad of the center, and composed of relatively slender segments. Species: *C. baeri* (Meek and Worthen), Whitewater formation of the Richmond of the Ohio valley; *C.? canyonense* Foerste, Fremont limestone, Colorado; *C. hercules* (Billings) English Head formation, Anticosti; *C. laddi* Foerste Maquoketa shale, Iowa; *C. rotundum* Troedsson, Cape Calhoun series, Greenland; *C. schucherti* Foerste, Trenton (?) Baffin Land; *C.*, sp. indet. (2 sp.), Troedsson, Cape Calhoun series, Greenland; *C.* sp. (listed) Kay, Stewartville dolomite, Minnesota.

Charactocerina Foerste (1935, p. 85). This genus differs from *Charactoceras*, with which it agrees in coiling and section, mainly in the costae on the dorsolateral region of the conch. The species are *C. costulata* (Miller), Big Horn formation; *C. faberi* (James), Whitewater formation, Ohio and Indiana; *C. multicamerata* Foerste, Big Horn formation, Wyoming; *C. plicata* (Whiteaves), Red River series, Manitoba; *C. washakiensis* (Miller), Big Horn formation, Wyoming.

Deckeroceras Foerste (1938, p. 92) is more rounded in section but retains the ventral lobes of the sutures. The siphuncle is located between the center and the venter and is similar in outline to that of *Apsidoceras*. The mature living chamber is slightly inflated. The whorls are free, and the complete shell was cyrtoconic to gyroconic. Species are *D. adaense* Foerste, Fernvale formation, Oklahoma; *D. clermontense* Foerste, Elgin member, Maquoketa shale, Iowa; *D.* sp. Foerste, Maquoketa shale, Iowa.

Fremontoceras Foerste (1938, p. 89), which includes only the genotype, *F. loperi* Foerste of the Fremont limestone of Colorado, is a coiled form in which the whorls may be in contact but no impressed zone is developed. The section is quadrangular, the ventral face the strongest, and lobes are developed on the sutures of this face. The siphuncle lies slightly ventrad of the center of the shell. The structure of its segments is not known. The genus may prove to be intermediate between *Wilsonoceras* and *Apsidoceras*.

In the development of coiled nautiloids with cyrtochoanitic subcentral siphuncles, broad whorls and lateral costae, the Apsidoceratidae are homeomorphic with the Devonian Rhadinoceratidae. The most perfect homeomorphy is found in comparing the Ordovician *Charactocerina* of the Apsidoceratidae with the Middle Devonian *Triplooceras* of the Rhadinoceratidae. Both are broad-whorled coiled cephalopods with an impressed zone, some development of costae, and a cyrtochoanitic siphuncle, which is well removed from the venter. *Triplooceras* may be distinguished by the absence of ventral lobes of the sutures and the more dorsal position of the siphuncle. As will be shown elsewhere, the two families are not at all closely related. The Rhadinoceratidae trace their ancestry through *Baeopleuroceras* and *Sphyradoceras* to orthochoanitic coiled costate Silurian cephalopods. Probably the Silurian ancestors of this

line are *Bickmorites* and *Tyrelloceras*, which are believed to be derived from *Centrocyrtoceras* of the Ordovician.

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JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 264–270, PLS. 42, 43, 1 TEXT FIG., MAY, 1943

EARLY DEVONIAN PLANTS FROM NEWFOUNDLAND

ERLING DORF
Princeton University, Princeton, N. J.
AND
JOHN R. COOPER
Ohio Wesleyan University, Delaware, Ohio

ABSTRACT—About 25 specimens of flattened spiny stems and dicotomous branches were collected by Cooper in southwestern Newfoundland from beds provisionally named the Bay du Nord series. These rocks were previously regarded as Pre-Cambrian. The plant specimens are referable to two species, *Drepanophycus spinaeformis* Göppert (=*Arthrostigma gracile* Dawson) and *Taeniocrada* cf. *T. decheniana* (Göppert) Kräusel and Weyland. Remains of the former species have hitherto been recorded from only two localities in North America; the latter species has previously been doubtfully recorded in North America. On the basis of the European occurrences of these species the plant-bearing beds are placed in the Lower Devonian. It is also concluded that the plant-bearing beds of the lower Gaspé sandstone of Gaspé Bay and of the Campbellton beds of New Brunswick are likewise referable to the Lower Devonian.

THE FOSSIL plants on which this paper is based were discovered during the summer of 1940 by Mr. Cooper, who was at that time engaged in mapping the La Poile-Cinq Cerf area (fig. 1) for the Newfoundland Geological Survey. A comprehensive description of the area is now in the hands of the Government Geologist of Newfoundland, but its publication is being delayed because of the war. The plant remains are of general interest because: (1) no Early Devonian plants have previously been known from Newfoundland; (2) they belong to species of which one is still only doubtfully known in North America, the other recorded from only two localities, although both species are well known in Europe; and (3) they indicate that some of the metamorphic rocks previously supposed to be of Pre-Cambrian age are actually Devonian, thus raising the question as to the age of adjacent metamorphosed sediments and volcanics long considered Pre-Cambrian. Since the plant-bearing beds are cut by granites which are lacking from unconformable (and unmetamorphosed) Carboniferous rocks lying respectively 22 miles northwest and 65 miles northeast of the fossil locality, the occurrence of Devonian granites in Newfoundland is now proved. This conclusion has been assumed heretofore on the basis of analogy with New England and maritime Canada, although no granites in Newfoundland were known to intrude rocks younger than Silurian.

OCCURRENCE

The plant impressions occur in a grayish-black slate, which, with associated graywacke and conglomerate, forms a belt 1 to 2 miles wide between younger acidic intrusions. The locations of this belt and of the fossil locality are shown in figure 1. Lithologically similar but unfossiliferous rocks are found elsewhere in the area. All of these, including the plant-bearing beds, are provisionally called the Bay du Nord series from exposures around the northern arm of La Poile Bay, where the thickness of the series is between 10,000 and 15,000 feet.

North of the fossiliferous belt, nothing but igneous intrusions and gneiss was seen. To the south, however, lies the type Bay du Nord series as well as an area of acidic volcanics (La Poile series) and several of paraschist. The type Bay du Nord series forms a band 1 to 3 miles wide, following the north arm of La Poile Bay and the lower 9 miles of the La Poile River, both of which are strike-controlled. Igneous intrusions separate this band from the volcanic La Poile series as well as from the plant-bearing beds.

To the west of the area lies the Long Range axis of Pre-Cambrian gneiss and schist cut by intrusions of granite, anorthosite, etc. The lower Cambrian lies unconformably above these rocks in Labrador (Schuchert and Dunbar, 1934, pp. 17–18) and northern Newfoundland (Betz, 1939, pp. 12–13); in the Bay St. George area,

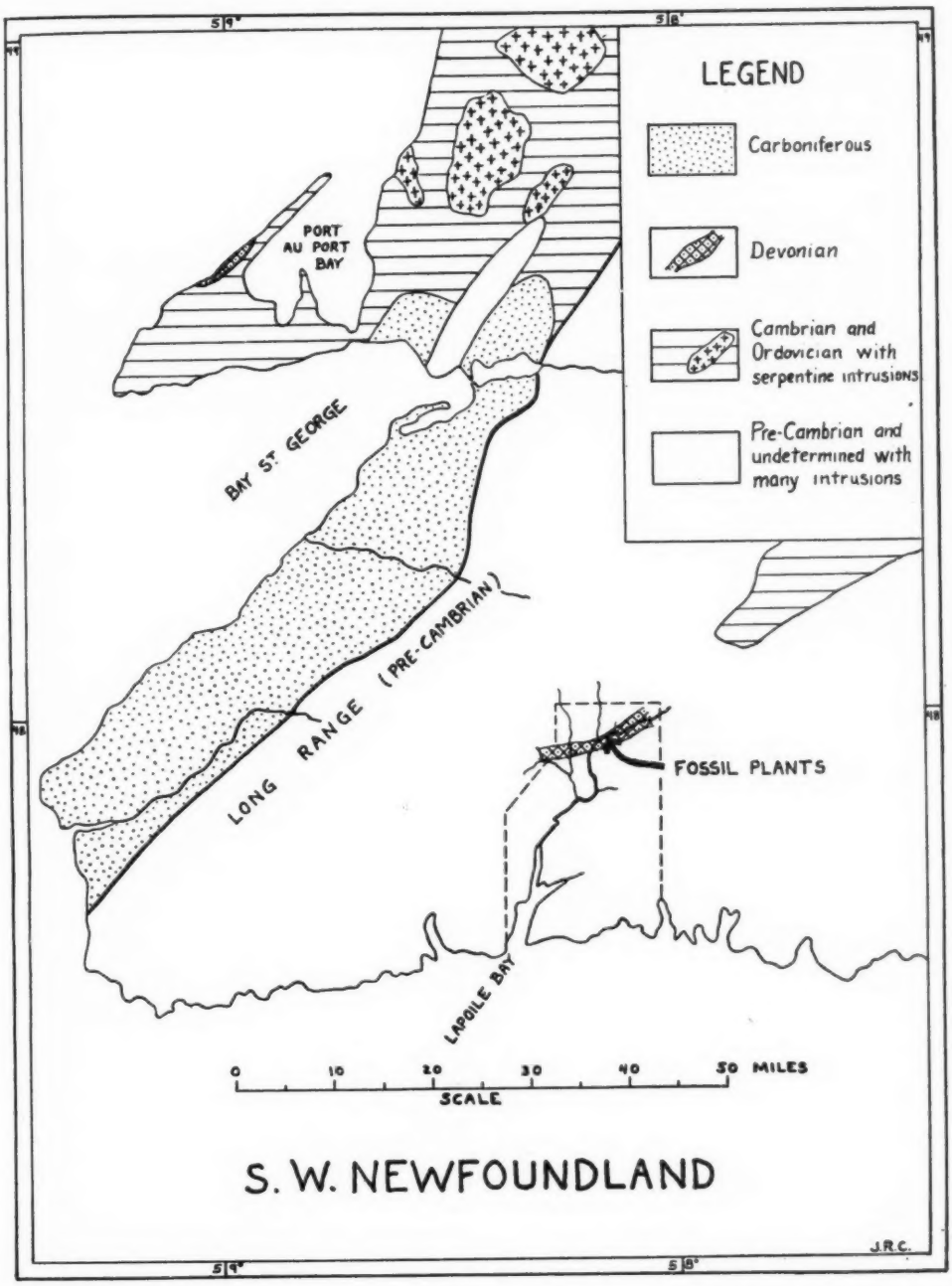

FIG. 1—Southwestern Newfoundland. The LaPoile-Cinq Cerf area is outlined by dashed lines, and the new fossil-bearing locality is shown.

however, the lower Paleozoic rocks are cut out by westward thrusting of the Pre-Cambrian crystalline rocks over Carboniferous strata (Hayes and Johnson, 1938, pp. 7–9).

To the northeast of the plant-bearing belt lies the volcanic Buchans series, considered Ordovician by Newhouse, Snelgrove, and others because of petrographic similarity to fossiliferous strata of Notre Dame Bay (Newhouse, 1931, pp. 401, 402; Snelgrove, 1938, p. 20).

Far to the east of the area, in southeastern Newfoundland, there is a late Pre-Cambrian volcanic series (Avondale volcanics) overlain by the thick Avalonian series of slates, quartzites and conglomerates (Buddington, 1919, pp. 455–472). These may be traced with assurance as far west as Fortune Bay, 100 miles east of the La Poile-Cinq Cerf area, where small masses of Cambrian strata lie unconformably on volcanics along the coast.

The relationships of the newly discovered Devonian rocks of the La Poile valley to these outlying series to the east, as well as to the Pre-Cambrian to the west and the Ordovician to the northeast, are problems of Newfoundland geology awaiting future solution.

AGE OF BEDS

On the basis of the plant remains the fossiliferous beds of the Bay du Nord series are here interpreted as belonging to the Lower Devonian.

Of the two species recognized in the collection the well-defined and numerous impressions of *Drepanophycus spinaeformis* offer the best evidence for an age determination. This species is abundantly represented at widely scattered localities in Europe and Asia; it is unequivocably regarded as confined to the Lower Devonian (Halle, 1916, pp. 13, 33; Lang, 1932, p. 491; Kräusel and Weyland, 1930, p. 77; Corsin, 1933, p. 180; Halle, 1936, p. 23; Höeg, 1937, p. 573). In Belgium (Stockmans, 1940, pp. 78–79) and Germany (Kräusel and Weyland, 1935, pp. 177, 184) the species is restricted to the upper half of the Lower Devonian. In a recent review of the Devonian floras of the world Kräusel (1937, p. 529) considers the genus *Drepanophycus* as one of the 11 characteristic genera of the *Psilophyton* flora of the Lower Devonian. To the writers' knowledge there are only two purported occurrences of the genus above the Lower Devonian in Eurasia: the misidentified *Arthrostigma* sp. from the Middle Devonian of Norway (Höeg, 1931, pp. 4–6), subsequently correctly referred to *Thursophyton* (Höeg, 1935, p. 10); and the Bohemian Middle Devonian species *Drepanophycus spinosus* (Krejci) Kräusel and Weyland (1933, p. 28), which differs materially from other species of the genus and might better be referred to *Thursophyton*.

In North America *Drepanophycus spinaeformis* has previously been recorded from only two localities: one in the lower Gaspé sandstone of the Gaspé Bay area, the other in the so-called Campbellton beds near Campbellton, New Brunswick (Dawson, 1871, pp. 4, 41, 72; 1882, pp. 102–104). At each of these localities the species is associated with *Psilophyton princeps* and other typical members of the Lower Devonian *Psilophyton* Flora. Furthermore, associated fish remains at Campbellton substantiate an assignment of the beds to the Lower Devonian (Romer and Grove, 1935, p. 814). Unfortunately, however, the invertebrates of the Gaspé sandstone have been the basis of conflicting conclusions regarding their age. Logan originally (1863, p. 394) regarded the lower Gaspé sandstone as Oriskany, i.e., Lower Devonian. Subsequently, Clark (1908, p. 86) placed the beds in the Middle Devonian; Williams (1910, pp. 691–694) placed them in the Lower Devonian; Parks (1931, p. 794) in the Middle Devonian; E. M. Kindle (in Jones, 1930, p. 20) in the transition between Lower and Middle Devonian; and C. H. Kindle (1936, p. 4) in the Middle Devonian ("probably").

Recent investigation of the mollusks and brachiopods of the Gaspé sandstone by G. Arthur Cooper (written communication,

EXPLANATION OF PLATE 42

FIGS. *1–6—Drepanophycus spinaeformis* Göppert. *1–5*, Bay du Nord series, La Poile-Cinq Cerf area, Newfoundland. Princeton University, nos. 9, D1, 11, 4, 6; ×1. Matrix slightly darkened in *5*. *6*, Bay du Nord series, La Poile-Cinq Cerf area, Newfoundland; Princeton University no. 4a, ×½. Matrix slightly darkened. (p. 267)

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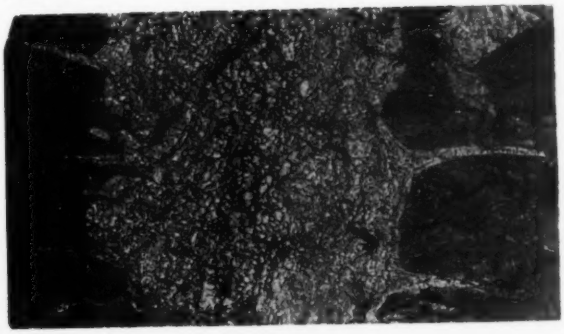

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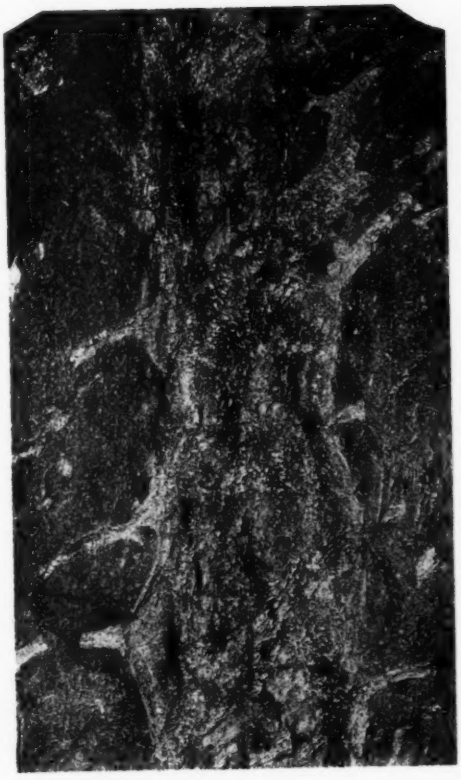

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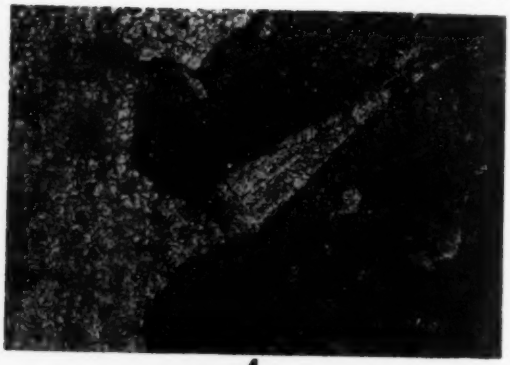

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Dorf and Cooper, Early Devonian Plants from Newfoundland

April 17, 1942) indicates that the fauna is of Camden chert (equals Schoharie) age, which Cooper now places in the upper part of the Lower Devonian. This would be in essential agreement with the plant evidence, as here interpreted.

There is, however, no reason why the evidence based on the plant remains in the Gaspé sandstone should in any way be affected by the uncertainty concerning the age assignment of the associated invertebrates. Until definitely proven otherwise, *Drepanophycus spinaeformis* is here regarded as indicative of a Lower Devonian assignment. Such an assignment for the lower Gaspé sandstone, as well as for the Campbellton beds and the plant-bearing Bay du Nord beds of Newfoundland, is further substantiated by: (1) the reported presence of *D. spinaeformis* in the Sextant formation of the Hudson Bay region, where the plant-bearing beds are overlain by beds of Onondaga age (Bell, written communication, March 7, 1942); (2) the presence in the Newfoundland beds of forms closely resembling *Taeniocrada decheniana*, which is recorded in Belgium, France, and Germany only in the Lower Devonian.

DESCRIPTIONS

Order PSILOPHYTALES
Family PSILOPHYTACEAE Hirmer
Genus DREPANOPHYCUS Göppert

Drepanophycus GÖPPERT, *1852*, K. Leop.-Carol. Akad. Naturfor. Verh., Bd. 22, suppl., p. 92.

DREPANOPHYCUS SPINAEFORMIS Göppert
Plate 42, figures 1–6; plate 43, figures 4–7

Drepanophycus spinaeformis GÖPPERT, *1852*, *idem.*, p. 92, pl. 41, fig. 1.

Drepanophycus spinaeformis, SANDBERGER, *1856*, Rhein. Schichten-syst., Lief. 9, p. 425, pl. 38, fig. 2.

Drepanophycus spinaeformis, GÖPPERT, *1860*, K. Leop.-Carol. Akad. Naturfor. Verh., Bd. 27, p. 443.

Arthrostigma gracile, DAWSON, *1871*, Fossil plants Devonian and Upper Silurian: Canada Geol. Survey, p. 41, pl. 13.

Arthrostigma gracile, DAWSON, *1882*, *idem.*, pt. 2, p. 104, (not pl. 24, fig. 22).

Drepanophytum spinaeforme, WEISS, *1889*, Deutsch. Geol. Gesell. Zeitschr., Bd. 41, pp. 167, 554.

Arthrostigma gracile, KIDSTON, *1894*, Royal Phys. Soc. Proc., vol. 12, p. 109, pl. 3, figs. 1–4.

Arthrostigma gracile, HALLE, *1916*, K. Svenska Vetensk. Handl., Bd. 57, pt. 1, p. 6, pl. 1, figs. 1–20, pl. 4, figs. 1–5.

Arthrostigma gracile, KRÄUSEL and WEYLAND, *1923*, Senckenbergiana, Bd. 5, heft 5/6, p. 166.

Arthrostigma gracile, HALLE, *1927*, Palaeontologia Sinica, ser. A, vol. 1, fasc. 2, p. 2, pl. 1, fig. 1.

Arthrostigma gracile, STEINMANN and ELBERSKIRCH, *1929*, Niederrhein. geol. Vereins Sitzungsber., p. 34, text fig. 10.

Drepanophycus spinaeformis, KRÄUSEL and WEYLAND, *1930*, Preuss. geol. Landesanst. Abh., n. Folge, Heft 131, p. 20, pl. 2, figs. 2–5; pl. 3, figs. 2–4; pl. 4, figs. 1, 7; text figs. 10–20.

Arthrostigma gracile, LANG, *1932*, Roy. Soc. Edinburgh Trans., vol. 57, pt. 2, no. 17, p. 494, pl. 1, figs. 1–16; pl. 4, fig. 71.

Arthrostigma gracile, CORSIN, *1933*, Acad. Sci. Paris, Comptes rendus, vol. 197, p. 180.

Drepanophycus spinaeformis, KRÄUSEL and WEYLAND, *1935*, Palaeontographica, vol. 80B, p. 177, pl. 41, figs. 1–19; pl. 42, figs. 1–3; pl. 44, fig. 8; text figs. 4–7.

Drepanophycus spinaeformis, HALLE, *1936*, Palaeontologia Sinica, ser. A, vol. 1, fasc. 4, pp. 5, 6, 23; pl. 1, figs. 1–10.

Drepanophycus spinaeformis, KRÄUSEL, *1937*, Cong. Av. Étud. Strat. Carb. (2nd), Heerlen, Compte rendu, vol. 2, pp. 527–537.

Arthrostigma gracile, HEARD, *1939*, Geol. Soc. London Quart. Jour., vol. 95, pt. 2, p. 226, pl. 12, fig. 5.

Drepanophycus spinaeformis, STOCKMANS, *1940*, Musée royal histoire nat. Belgique Mém. no. 93, p. 56, pl. 5, figs. 1–3; pl. 7, figs. 1, 5, 10–12; pl. 8, fig. 5; pl. 9, figs. 3–6; pl. 12, figs. 1, 11–16.

The majority of the plant remains from the Bay du Nord series consist of about 25 impressions of flattened stems or branches bearing large marginal spiny leaves. The stems range from 1.8 to 3.5 cm. in width, averaging about 2.5 cm.; their lengths are indeterminable because of the fragmentary nature of the specimens. For the most part the stem impressions have preserved none of the carbonaceous residue of the original plant; in a few instances, however, as in plate 42, figure 1, and plate 43, figure 7, the medial portion of the stem is marked by a thickened band of carbonaceous matter, presumably the remnants of the central

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EXPLANATION OF PLATE 43

FIGS. *1–3*—*Taeniocrada* cf. *T. decheniana* (Göppert) Kräusel and Weyland. Bay du Nord series, La Poile-Cinq Cerf area, Newfoundland. Princeton University nos. 22 to 24, ×1. (p. 269)

4–7—*Drepanophycus spinaeformis* Göppert. *4*, Bay du Nord series, La Poile-Cinq Cerf area, Newfoundland; Princeton University no. 8a; ×3. *5–7*, Bay du Nord series, La Poile-Cinq Cerf area, Newfoundland; Princeton University nos. 12, 6a, 8; ×1. (0. 267)

vascular strand (stele). In other specimens fine narrow longitudinal furrows and ridges probably are the only remaining expression of the central strand. The spiny leaves can be seen only in profile along both margins of the stems. Where they can be measured, the leaves range from 1.0 to 2.4 cm. in length and are on the average slightly shorter than the width of the flattened stems to which they are attached. They are broadened at the base of attachment and are curved slightly upward or downward to blunt tips. Some of the leaves, as in plate 43, figure 4, are faintly marked by a longitudinal line which may be the impression of a vein or of an edge of a more or less angular leaf.

The combination of observable characters noted above makes it obvious that these impressions are referable to the widespread Early Devonian species known in the past either as *Drepanophycus spinaeformis* Göppert or *Arthrostigma gracile* Dawson.

The genotype of *Drepanophycus spinaeformis* was collected from the "Spiriferensandstein" (Siegenerschichten) near Hachenburg, province of Nassau, Germany. The single specimen obtained was figured in 1852 by Göppert, who defined the species as follows:

D. [*Drepanophycus*] fronde plana ecostata compressa membranacea ciliata, ciliis vel foliis alternis basi sub triangularibus sursum falcatis enerviis.

Most of the Newfoundland specimens are essentially similar to the described and observable details of the genotype; others differ only in their somewhat greater width.

Except for incidental references to the genotype, this species received little attention during the next two decades. In 1871, however, Dawson described some impressions of essentially similar character as *Arthrostigma gracile* Dawson. These had been collected from the lower Gaspé sandstone of the Gaspé Bay region. Dawson did not mention the similarity of the Gaspé specimens to Göppert's *Drepanophycus spinaeformis*. During the next 60 years the relation between the genera *Drepanophycus* and *Arthrostigma*, and between their component species, remained in doubt. It was not until 1930 that Kräusel and Weyland (1930, p. 20), after restudy of Göppert's genotype, demonstrated the identity of the two genera. By rule of priority the name *Drepanophycus* Göppert, though unfortunately intimating algal relationships, was rightly considered the valid epithet. The same authors further considered Göppert's species and Dawson's species as identical, a view which has subsequently been almost universally accepted. The attempt by Weiss (1889, pp. 167, 554) to change the generic name to *Drepanophytum* because of the algal connotation of the name *Drepanophycus* was obviously illegitimate and has fortunately been disregarded.

Since 1871, specimens referred to either *Drepanophycus spinaeformis* Göppert or *Arthrostigma gracile* Dawson have been described from widely scattered localities in Europe, North America and Asia.

In 1882 Dawson described the occurrence of *Arthrostigma gracile* near Campbellton, New Brunswick, in beds which he considered equivalent to the lower Gaspé sandstone farther north. This occurrence, together with the original occurrence in the Gaspé Bay area and the Newfoundland occurrence of the present paper, are the only published accounts of the presence of this species in North America. Bell has recently reported (letter of March 7, 1942) that he has seen specimens of *A. gracile* also in collections from the Sextant formation of the Hudson Bay region and from the McAdam Lake formation of Sydney coalfield, Cape Breton Island.

In 1894 Kidston wrote of the occurrence of *A. gracile* in the lower Old Red sandstone of Scotland. Several of his specimens, in particular plate 3, figure 1, are virtually identical with the Newfoundland specimens. Other occurrences of the species in the British Isles have been reported by Lang (1932, p. 494) from the lower Old Red of Scotland, and by Heard (1939, p. 226) from the Senni beds of South Wales.

In 1916 Halle recorded the presence of *Arthrostigma gracile* in the Lower Devonian of Röragen, Norway. The specimens which he figured on plate 1, figures 9 and 10, are identical in essential features with the Newfoundland impressions. Halle was the first to demonstrate the vascular structure of the stems of this species.

In 1923 Kräusel and Weyland reported the occurrence of *Drepanophycus spinaeformis* in the Lower Devonian of Hachenburg, Germany. Other occurrences of the

species in Germany were subsequently recorded by these same authors in 1930 and 1935. In the latter reports *Arthrostigma gracile* was referred to *Drepanophycus spinaeformis* Göppert on the basis of the reexamination of the Hachenburg specimen believed to be Göppert's genotype; the authors also demonstrated for the first time the existence of spore cases, with enclosed spores, attached to the spiny leaves of the species.

Other European occurrences of the species include the Lower Devonian of Pas-de-Calais, France, reported in 1933 by Corsin, and the Lower Devonian of eight localities in Belgium, reported in 1940 by Stockmans.

Asiatic records of the species are apparently confined to the Chinese localities listed by Halle in 1927 and 1936. In the latter report Halle accepts *Drepanophycus spinaeformis* Göppert as the valid name of the species. Of the specimens figured in this paper those on plate 1, figures 1 and 2, are very similar to those from Newfoundland except for their slightly more closely spaced leaves.

The single reported occurrence of the species in the southern hemisphere is that of the Upper Silurian (?) Jordan River beds of Victoria, Australia, described by Cookson (1926, pp. 66–68). This specimen has since been correctly transferred to a different genus, *Baragwanathia* Lang and Cookson (1935, p. 428).

From the numerous specimens studied, the complete characters and the habit of *Drepanophycus spinaeformis* have gradually come to be fairly well known. It was apparently a vascular terrestrial plant not exceeding 40 cm. in height; the stem was cylindrical in cross section and possessed a central strand of xylem composed of annular tracheides; the epidermis of the stem occasionally shows elongated cells and numerous well-defined stomata; the marginal emergences of the stem have in cases of exceptionally fine preservation been found to have true stomata and slender vascular traces passing inward to the central strand, and are consequently generally regarded as essentially true leaves; these spiny leaves are apparently spirally arranged on the stems, are basally enlarged and bluntly tipped, and are curved either slightly upward or downward; the upper surfaces of some of the leaves have been found to bear stalked sporangia whose content of true spores has been clearly demonstrated. An excellent reconstruction of the species is figured by Kräusel and Weyland (1935, text fig. 7).

The systematic relationships of *D. spinaeformis* are not too definitely established. Although approaching certain species of *Psilophyton* in recognizable characters, the species can generally be distinguished by the large size and wide spacing of the spiny leaves, and, where preserved, also by its sporangia and by definitive histological differences in cuticle and stomata. The species is at present regarded as a microphyllous Pteridophyte, very close to or a forerunner of the true lycopods of later Devonian time.

Occurrence.—Bay du Nord series, La Poile-Cinq Cerf area, southwestern Newfoundland.

Hypotypes.—Nos. 4, 4a, 6, 6a, 8, 8a, 9, 11, 12, D1, on deposit at Princeton University.

Genus TAENIOCRADA White

TAENIOCRADA cf. T. DECHENIANA (Göppert) Kräusel and Weyland

Plate 43, figures 1–3

Taeniocrada decheniana (GÖPPERT) KRÄUSEL and WEYLAND, *1930*, Preuss. geol. Landesanstalt Abh., n. Folge, Heft 131, pp. 33–41, pl. 4, figs. 2–5; pl. 5, figs. 1, 2; pl. 6, figs. 3, 4; pl. 7, fig. 1; pl. 8, figs. 3, 4; text-figs. 23–25; (complete synonymy on p. 40).

The Newfoundland collection contains five specimens showing impressions of thin, smooth-margined, bandlike stems or branches with sharply defined central strands. The preservation of all the specimens leaves much to be desired. In the specimen shown on plate 43, figure 3, the impressions are closely packed and include several branches showing dichotomous branching. The average width of the branches is 4.0 mm.; the central strand is less than 0.5 mm. wide. The manner in which several of the branches are twisted and bent in the matrix suggests that they were originally somewhat flexible and delicate.

The characters of these impressions closely resemble those described for several species of *Taeniocrada*. Unfortunately, the inadequate state of preservation makes it impos-

sible to make a definite specific determination. It is noted, however, that the best resemblance is with the well-known species *T. decheniana*. In addition to its widespread occurrence in the Lower Devonian of Germany, recorded by Kräusel and Weyland, this species was reported from the Lower Devonian of France by Corsin (1933, p. 180) and from the Lower Devonian of Belgium by Stockmans (1940, pp. 39–41).

Kräusel and Weyland consider *T. decheniana* to have been a partially submerged vascular plant, bearing oval spore cases at the emergent extremities.

Occurrence.—Bay du Nord series, La Poile-Cinq Cerf area, southwestern Newfoundland.

Hypotypes.—Nos. 22–24, on deposit at Princeton University.

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JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 271–275, PLS. 44, 45, 4 TEXT FIGS., MAY, 1943

NEW COELACANTH FISHES FROM THE TRIASSIC OF NEW JERSEY

VINCENT E. SHAININ
U. S. Geological Survey, Washington, D. C.

ABSTRACT—Because of the lack of qualitative differences, fossil coelacanths from both the Stockton and Lockatong formations of the Newark group have been assigned to *Osteopleurus newarki* (Bryant), despite the fact that specimens from the Stockton are half again as large. Pelvic plates recently discovered in the Stockton show no structural relationship whatsoever to plates from Lockatong coelacanths, and on this basis a new species is described from the Stockton. In addition, a caudal fin, derived from a coelacanth at least one and four-fifths times as long as the average specimen from the Stockton, is described as a new variety from that formation.

FOSSILS of crossopterygian coelacanth fishes from the Upper Triassic of North America are extremely scarce; only three species have been described, and two of them are from the Newark group, which occurs in narrow fault troughs along the Atlantic Coast. In the New York-Virginia trough the group is divided into three formations, which are, in ascending stratigraphic order, the Stockton, the Lockatong and the Brunswick.

Newberry (1878) named *Diplurus longicaudatus* from the Brunswick formation, and this was the only Upper Triassic coelacanth fish known from North America until Lambe (1916) described *Coelacanthus banffensis* from Alberta, on the basis of a single fin. In 1934 Bryant named *Coelacanthus newarki* from the Lockatong formation, and fossil coelacanths discovered subsequently in the upper part of the Stockton formation at Granton quarry, North Bergen, New Jersey, were assigned to the same species by Schaeffer (1941), but he revised the generic name from *Coelacanthus* to *Osteopleurus* on the grounds that certain characteristics, chiefly the long ossified pleural ribs, indicated too much deviation from the Permian genotype, *Coelacanthus granulatus*, Agassiz.

Specimens of *Osteopleurus* from the Stockton formation are nearly half again as large as those from the Lockatong. This difference in size was recognized by Schaeffer, but lacking qualitative evidence to supplement the quantitative difference, he admitted that no basis existed for a specific differentiation. Newly discovered specimens of coelacanths from the Stockton formation at Granton quarry now prove the existence of qualitative differences between fish occurring in the two formations, and on this basis *Osteopleurus milleri*, n. sp., is described here.

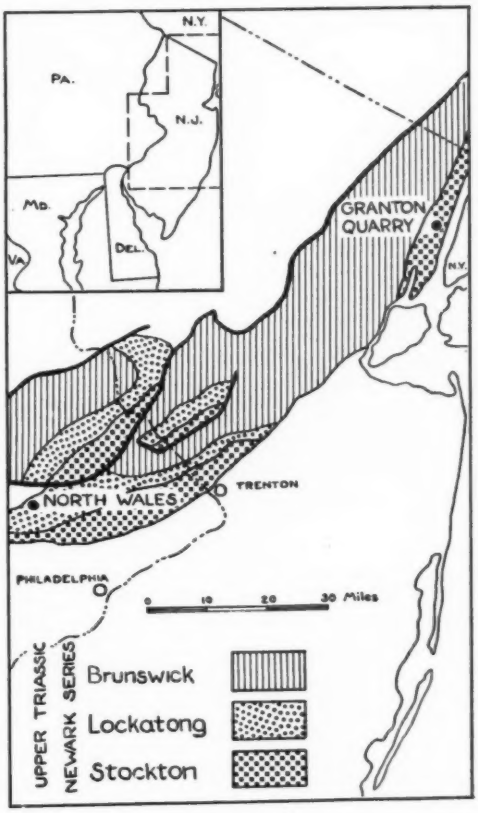

FIG. 1—Geologic sketch map showing location of Granton quarry in New Jersey, the type locality of *Osteopleurus milleri* Shainin, n. sp., and *O. m. grantonensis* Shainin, n. var., and North Wales, Pa., the type locality of *O. newarki* (Bryant). Inset shows the location of the geologic map.

In addition, a caudal fin collected at Granton quarry is so large that it must have been derived from a coelacanth fish nearly twice as long as the average *O. milleri*. It is described here as *Osteopleurus milleri grantonensis*, n. var.

The writer is deeply grateful to Mr. S. S. Oriel, a student in geology at Columbia University, for the discovery and presentation of the type *O. m. grantonensis*, and to Mr. M. Patterson, of the Department of Geology at Columbia University, for the use of specimens in his private collection. He is also indebted to Dr. W. K. Gregory, of the American Museum of Natural History, for his advice, to Dr. H. N. Coryell, Miss Ruth Schmidt and Mr. Sherman Neuschel, of the Department of Geology at Columbia, for their suggestions on taxonomic procedure, to Dr. G. M. Conrad, of the American Museum of Natural History, for permission to examine the Museum's collection of fossil coelacanths, and to Mr. M. L. Gabriel, of the Department of Zoology at Columbia, for his council on ichthyological morphology.

The new specific name is chosen in honor of Dr. Ralph L. Miller, of Columbia University, under whose direction this study was initiated, and the variety is named after Granton quarry, the type locality.

SYSTEMATIC DESCRIPTIONS

Class PISCES
Subclass GANOIDEI
Order CROSSOPTERYGII
Family COELACANTHIDAE
Genus OSTEOPLEURUS Schaeffer, 1941

Bryant (1934), had reported that the opercular plate of the skull of the genus was ornamentated with "fine granulations," but Schaeffer (1941) either overlooked this or supposed that the new material available to him showed Bryant to be mistaken, for he states that "an isolated example (of the operculum) shows that it . . . lacks ornamentation." However a recently discovered opercular plate (fig. 2) shows distinct surface ornamentation; therefore this feature would seem to be characteristic of the genus though not peculiar to it.

Although the new species recorded below shows a major structural divergence from the genus as described by Schaeffer in the shape of the pelvic plates, it parallels closely the genotype in respect to many other significant features, particularly in the long pleural ribs, so that until more material becomes available, giving a more complete picture of the differences between *O. newarki* and *O. milleri*, there does not appear to be sufficient evidence for the establishment of a new genus.

OSTEOPLEURUS MILLERI
Shainin, n. sp.
Plate 44, figures 1, 2; plate 45, figs. 2, 3; text figs. 2, 3A.

Coelacanthus newarki (part) BRYANT, *1934*, Amer. Philos. Soc. Proc., vol. 73, no. 5, p. 323, pls. 5–8.

Dimensions.—The average measurements, in millimeters, are as follows:

Body length (minus supplementary caudal)	105
Head length	28
Length from posterior border of head to anterior border of caudal	47
Length of first caudal	30
Length of supplementary caudal	10
Fin locations: From anterior end	
to first dorsal	34
to second dorsal	55–60
to pelvic	43
to anal	66
to caudal	75

Axial skeleton.—From 25 to 30 mm. long, ossified, subperitoneal, pleural ribs are present. The neural arches are widely forked, with long neural spines, which are well ossified and usually preserved intact. Parapophyses are about one-half as long as neural arches but are rarely preserved. Well-developed haemal arches occur posterior to the last rib. (See pl. 44, figs. 1, 2.)

Paired fins and girdles.—The pectoral fin is poorly preserved or absent on all speci-

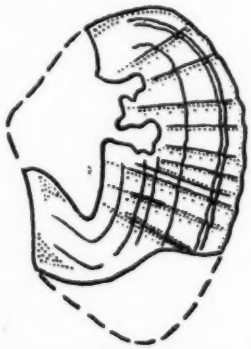

FIG. 2—*Osteopleurus milleri* Shainin, n. sp. Opercular plate showing surface ornamentation, ×3.5.

mens. The pelvic plates (text fig. 3A; pl. 45, fig. 2) possess an anterior portion (using the terminology of Stensio, 1932) consisting of three elongate apophyses, of which the center one is shortest, a vertical medial process subnormal to the anterior apophyses, and a broad, knoblike posterior division.

The pelvis naturally falls into a group of structurally related pelves represented by *Rhabdoderma elegans*, *Coelacanthus granulatus*, *Undina*, *Macropoma*, and *Wimania*. The plate of *Rhabdoderma*, which is typical of the group, is compared in text figure 3 with the pelvic plate of typical *O. milleri* and with that of *O. newarki*. The plate of *O. newarki* differs strikingly from both of these forms. In the *Rhabdoderma* type, the medial processes of the plates on each side of the body articulated with each other to form a girdle, while the body and fin musculature were attached to the anterior and posterior divisions. The proximal endoskeletal somactidia(ae) of the pelvic fin articulated with the posteroventral portion of the posterodivision.

In addition to the pelvic plate of the holotype, another rather poorly preserved but well-orientated plate shows clearly the narrow medial process and what appears to be the broken base of one of the anterior apophyses.

Unpaired fins and basal plates.—The anterior dorsal fin consists of nine laterally flattened and grooved lepidotrichia; the basal plate is triangular, with the apex pointing anteriorly. The lepidotrichia, which are faintly jointed in their distal portions, are forked at the proximal ends to fit over the basal. Neither the basal plate of the posterior dorsal nor that of the anal is known (in *O. newarki* both of these plates are slender and bifurcated), but the fins contain approximately 12 lepidotrichia and 8 lepidotrichia, respectively. Each lobe of the diphycercal caudal fin contains 11 or 12 widely jointed lepidotrichia, while the supplementary caudal consists of about 22 dermal rays and is longer in proportion to the body length than that of most coelacanths.

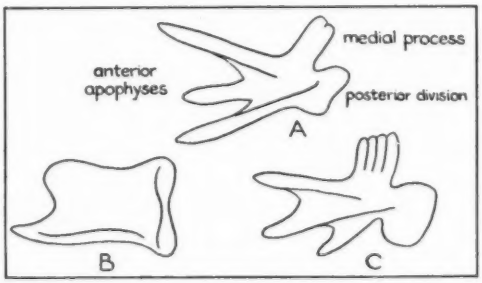

FIG. 3—Left side of pelvic plates; scales various, approximately ×4.3.
A, *Osteopleurus milleri* Shainin, n. sp. Holotype.
B, *Osteopleurus newarki* (Bryant). After Schaeffer.
C, *Rhabdoderma elegans* (Newberry). From Schaeffer after Moy-Thomas.

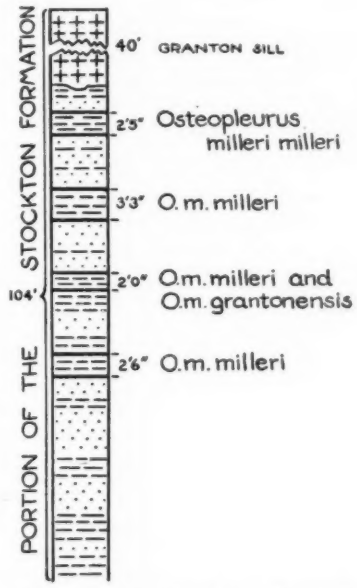

FIG. 4—Columnar section of rocks exposed in Granton quarry, North Bergen, N. J., showing the horizons in which coelacanth fishes occur.

Squamation.—The scales are roughly ellipsoid in shape and, in the exposed portion, bear about five longitudinal ridges, of which the middle one is usually the longest and most prominent. Fine striae ornament the surface and appear to converge in the covered portion of each scale. Some specimens show faint annular rings in the exposed part.

Skull plates.—The opercular plate bears radial striations and annular rings. The postorbital plate also shows radiating striae, which develop locally into mild plications (pl. 45 fig. 3). Annular rings of the type found in the operculum produce a pattern that simulates the growth lines of molluscs.

In fact, isolated postorbital plates of this species found in Granton quarry have been mistaken for Triassic pelecypods in more than one collection. It was not until specimens were found in fairly well preserved skulls that their true identity became known.

Type locality.—The only known locality is Granton quarry, North Bergen, Hudson County, New Jersey.

Age and horizon.—Upper Triassic. All of the specimens were collected from black shales belonging to the upper part of the Stockton formation of the Newark group. Four closely spaced horizons are known, ranging from 150 to 180 feet above the Palisades sill. The same horizons lie from 5 to 35 feet below the Granton sill. (See text fig. 4.)

Associated faunule.—The phyllopod crustacean *Estheria ovata* Lea and the coelacanth *O. milleri grantonensis*, are the only other fossils occurring in these beds. The shales probably have their origin in fresh-water lake beds.

Holotype.—Paleontological collection, Columbia University.

Paratypes.—American Museum of Natural History (no. 15222) and paleontological collection, Columbia University.

Discussion.—Prior to the writer's discovery of pelvic plates on specimens of *Osteopleurus* from the Stockton formation at Granton quarry, the only plates of the genus on record were those of the type *O. newarki* (Princeton Univ. Pal. Mus. no. 13695) from the Lockatong formation near North Wales, Pennsylvania. These plates were described by Schaeffer (1941), who wrote:

> A study of Bryant's original material has not revealed with certainty which is the lateral and which the medial borders of the plates. . . . In any event, the pelvic plates are very unlike anything previously described.

Both right and left plates of the pelvic girdle are well preserved on the type *O. newarki*, and, though there may be some question as to their orientation, there can be little doubt as to their shape, which is, as has been pointed out, strikingly dissimilar to the plates of typical *O. milleri*.

OSTEOPLEURUS MILLERI GRANTONENSIS Shainin, n. var.
Plate 45, figure 1

Dimensions.—Caudal length (minus supplementary caudal), 55+ mm.; caudal depth, 43+ mm.

Caudal fin.—The holotype consists of a diphycercal caudal fin and probably a portion of the end of the spinal column (pl. 45, fig. 1). What are possibly the most posterior haemal arches are present on the edge of the slab of black shale where the caudal impression became separated from the rest of the fossil. This would establish the dorsoventral orientation, since the haemal arches are ventral to the notochord.

Although the supplementary caudal is not present, its former existence in this specimen is indicated by the vacuity formerly occupied by the notochord, which extended mesially through the first caudal between the epichordal and hypochordal lobes without perceptible contraction. The same notochordial vacuity is present in the caudals of typical *O. milleri*, from which the supplementary caudals were probably detached before preservation due to their extreme fragility.

Each caudal lobe bears about 12 lepidotrichia and is similar to *O. milleri* in this respect. There is no unquestionable evidence of jointing in the lepidotrichia, although widely spaced joints may be present as in *O. milleri*.

The extreme distal portion of each lepidotrichium appears to have been broken off, since the terminations are not narrow and sharply pointed, as they are almost invariably in coelacanths. In the ontogenetic growth of most fishes, ossification commences in the proximal ends of the lepidotrichia and proceeds distally, so that lack of ossification because of immaturity may account for the relatively uniform destruction of the distal portion of each lepidotrichium. This interpretation, of course, necessitates that the original caudal be even larger than measured. One lepidotrichium of what is probably the hypochordal lobe has a disen-

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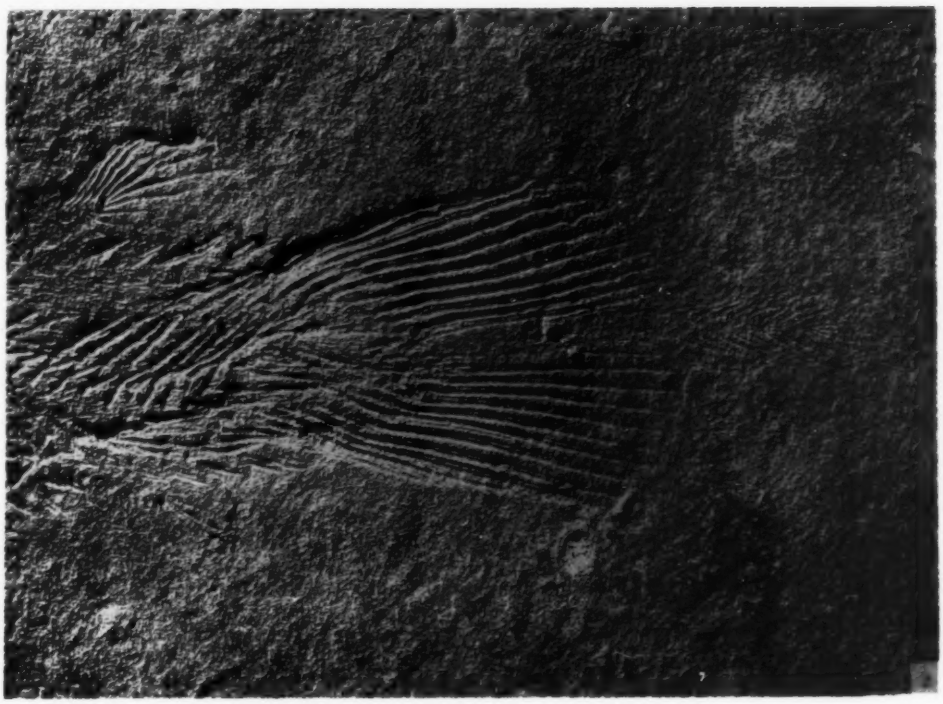
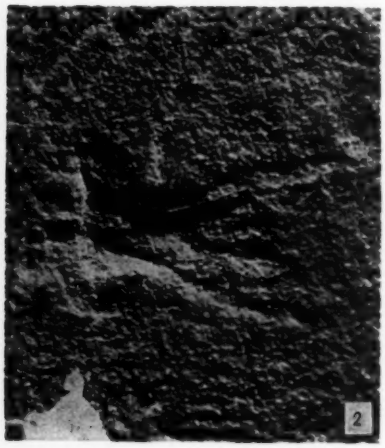
EXPLANATION OF PLATE 44

FIGS. *1, 2*—*Osteopleurus milleri* Shainin, n. sp. *1*, Specimen showing long ossified ribs, well-preserved neural spines, and grooved lepidotrichia, ×1.2; *2*, mold of the same showing supplementary caudal and vacuity between the epichordal and hypochordal lobes of the first caudal, formerly occupied by the notochord, ×1.9. Stockton formation, Newark group, at Granton quarry, North Bergen, N. J. (p. 272)



Shainin, Triassic Fish from New Jersey



Shainin, Triassic Fish from New Jersey

gaged segment that extends about 7 mm. beyond the general periphery of the broken terminations. However, even this segment appears to be a broken base, since it, too, has a blunt distal termination.

Type locality.—Granton quarry, North Bergen, Hudson County, New Jersey.

Age and horizon.—Upper Triassic. The holotype was collected in the upper part of the Stockton formation from a horizon 158 feet above the Palisades sill and 27 feet below the Granton sill.

Associated faunule.—Typical *O. milleri* and *Estheria ovata.*

Holotype.—Paleontological collection, Columbia University, New York City.

Discussion.—Assuming that the fish from which the caudal described above must have been derived was similar to typical *O. milleri* in proportion (the form and structure of the caudal show no contrary evidence), then the ratio of the caudal length to the body length of each should be the same. Using 30 mm. and 105 mm. as the caudal length and body length, respectively, of *O. milleri* and 55 mm. as the caudal length of *O. m. grantonensis*, the hypothetical body-length of *O. m. grantonensis* is found to be 192 mm., or 1.83 times as great as that of *O. milleri.* (Twelve specimens of *O. milleri*, collected from various horizons, show a maximum deviation in body length of not more than 6 per cent in excess of the mean.)

It is also of significance that an unlabelled coelacanthid bone in the American Museum of Natural History's collection of coelacanth fish (A.M.N.H. no. 15222) is strikingly similar in appearance to the postorbital skull plate of *O. milleri*, except that it measures 19 by 14 mm., whereas the average postorbital plate of *O. milleri* measures only 11 by 7 mm. A normal specimen of *O. milleri* would have had to have been more that 180 mm. long to have possessed such a large postorbital plate. This bone may well have been derived from *O. m. grantonensis.*

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EXPLANATION OF PLATE 45

FIG. *1—Osteopleurus milleri grantonensis* Shainin, n. var. Caudal fin, ×1.4. Holotype. Stockton formation, Newark group, at Granton quarry, North Bergen, N. J. (p. 274)

2, 3—Osteopleurus milleri Shainin, n. sp. *2*, Pelvic plate from the right side, holotype, ×9.0; anterior end at the right. *3*, Postorbital plate from the skull showing surface ornamentation, paratype, ×10.0. Both from Stockton formation, Newark group, at Granton quarry, North Bergen, N. J. (p. 272)

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 276–280, PL. 46, 1 TEXT FIG., MAY, 1943

NEW CHESTER CORALS FROM ALABAMA AND TENNESSEE

WM. H. EASTON
Illinois Geological Survey, Urbana, Ill.

ABSTRACT—Two new species of *Caninia* are described. The first true *Palaeosmilia* from North Amerca is described, and the relationships of the genus are briefly reviewed.

THIS PAPER continues a series begun by the writer in order to clarify and organize the morphology and systematics of some American Carboniferous corals. Practically nothing has been done in this field until comparatively recently, hence very little is known about American Carboniferous corals, whereas corals of the same age have been studied in great detail abroad. The terminology used in this paper is that of Hill (1935).

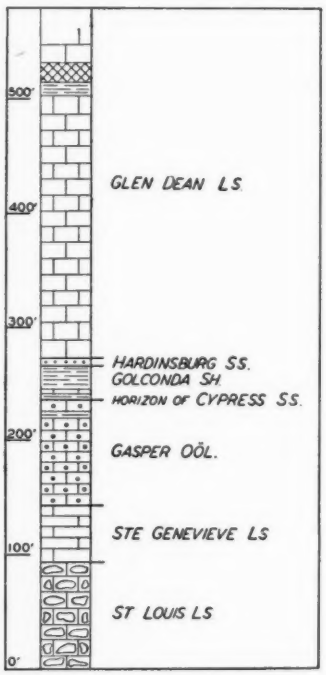

FIG. 1—Typical columnar section of part of the Mississippian strata near Sherwood, Tenn. After Butts (1926, pl. 49, part of sec. 16).

The corals herein described were collected by Mr. Charles Butts, who also furnished details as to stratigraphic position of the specimens. The writer is indebted to Mr. Butts for permission to section, study, and describe these specimens. The types are deposited in the United States National Museum and the peel sections are deposited in Walker Museum, University of Chicago.

In figure 1 the lowest St. Louis and the youngest Bangor limestones are not shown. The St. Louis and Ste. Genevieve limestones are lower Mississippian (Iowa series of Weller), and the overlying beds are in the upper Mississippian (Chester series). The Gasper oölite represents the Renault, Bethel, and Paint Creek of the Mississippi River valley section. The Cypress sandstone is locally absent near Sherwood, though it is present at some other places in the region. The Golconda shale is generally represented farther west by limestone. The Hardinsburg sandstone has maintained normal lithology. The Glen Dean limestone of this section represents the lower part of the Bangor limestone (restricted). The lower fifty feet of the Glen Dean horizon is rather shaly limestone. Only a few feet of the upper part of the Bangor are present here, and the Pennington formation, which overlies the Bangor, is not exposed at this section.

The St. Louis limestone is characterized by the presence of *Lithostrotion proliferum* in its basal members and by *Lithostrotion canadense* in its upper members. The Ste. Genevieve limestone is characterized by *Lithostrotion harmodites* almost everywhere and contains *Cystelasma quinqueseptatum*, *Michelinia princetonensis*, and *Michelinia subramosa* farther west. These last three may be looked for in the Appalachians. In addition, *Triplophyllum spinulosum* ranges through the Ste. Genevieve limestone and all through the Chester. *Lithostrotionella*

castelnaui may occur in the region, since it is known from near Cherokee, Ala., as well as from three localities in Virginia and from one in West Virginia. It occurs in the St. Louis, basal Newman, and basal Greenbrier limestone. *Lithostrotionella hemisphaerica* may also occur in this region, since it is known from the Greenbrier limestone of Virginia and West Virginia.

The Chester is not represented by many coral species. *Caninia veryi*[1] is characteristic of the Gasper at many places, including the region from which the corals now described came. *Amplexus geniculatus* is highly characteristic of the Shetlerville (basal Renault) of Illinois but has not been reported this far east. The Golconda carries one new species each of *Caninia* and of *Palaeosmilia*. The Glen Dean horizon of the Bangor limestone carries a new species of *Caninia*.

Phylum COELENTERATA
Class ANTHOZOA
Order TETRACORALLA
Family CANINIIDAE

Genus CANINIA Michelin (in Gervais), 1840

CANINIA TENNESSEENSIS Easton, n. sp.
Plate 46, figures 1–4

External characters.—Simple, curved ceratoid to cylindrical corallites exhibiting axial increase; calyx of unknown depth, flat-floored, except for the marked cardinal fossula; major septa extend part way across the floor; theca rather thick, marked by interseptal ridges, septal grooves, striae, and commonly by pronounced bourrelets. Specimens vary in length from 3 cm. to 10 cm. or more and in diameter from 1 cm. to 3 cm.

Transverse sections.—In late ephebic stage of the holotype (diameters 25 by 27 mm.), 40 major septa extend three-fifths of the radius; septa slightly dilated in the cardinal quadrants; cardinal fossula inconspicuous, the cardinal and adjacent septa are somewhat shortened, whereas the counter and adjacent septa are somewhat elongated; septa become disassociated into one or more plates at the junction of the tabularium and dissepimentarium; septal crests present in dissepimentarium; dissepimentarium occupies one-fourth to one-half the radius and consists largely of medium-large lonsdaleoid dissepiments; as many as five or six ranges of dissepiments adjacent to the tabularium may be somewhat concentric and are crossed by septa.

At a slightly later stage of the holotype (diameters 28 by 30 mm.) the dissepimentarium is proportionately wider and consists almost entirely of lonsdaleoid pattern of dissepiments.

In early neanic stage of a paratype (diameters 4.5 by 4.5 mm.), there are 24 major septa extending five-sixths of the radius; no fossula was observed, but about half the septa on one side are thin and undulatory, and one of these, which is slightly longer than the others, may be the counter septum; no dissepiments present; a few septal ridges observed.

In late neanic stage of another paratype (diameters 4.5 by 6.0 mm.) there are about 24 major septa, which extend about half the radius; three or fewer ranges of somewhat concentric dissepiments and also dissepiments of lonsdaleoid pattern are present; septa extend to theca only through concentric pattern; no certain indication of cardinal position observed other than a few possibly dilated septa.

Longitudinal sections.—In the holotype, the dissepiments are very steeply inclined; tabulae flat to broadly concave distally, recurved abruptly at the edges of the tabularium; tabulae irregularly spaced; incomplete tabulae uncommon; density variable, from 13 to 24 tabulae per cm.

In a paratype the dissepimentarium appears at the diameter of about 8 mm.

Comparisons.—This species differs from *Caninia juddi cambrensis* Lewis, in that this species has a less pronounced cardinal fossula, the lonsdaleoid pattern is instituted earlier and attains more importance, the dilation of septa is less pronounced, and there are fewer septa.

This species differs from *Caninia juddi dawsoni* (Lambe) Lewis in that there are more lonsdaleoid dissepiments, and there is no columellar structure in neanic stage.

Material.—The holotype, paratypes, and topotypes are in the United States National Museum.

Locality.—All the known specimens were collected by Charles Butts from the quarry

[1] This binomial will be explained in a forthcoming issue of this Journal.

by the railroad at Sherwood, Tenn., from what is probably Golconda limestone and shale. The specimens bear the number 533U and are Butts' field number "D" for the year 1919, in notebook 3135B, p. 47.

Remarks.—This species combines features of the *Caninia juddi* species group outlined by Hill (1939, p. 108) and the *Caninia cylindrica* species group outlined by Lewis (1924, p. 390).

CANINIA FLACCIDA Easton, n. sp.
Plate 46, figures 5, 6

External characters.—Compound, loosely bound, commonly phaceloid coralla, the colony consisting of rather straight ceratoid to cylindrical corallites; epitheca moderately thick, with rugae and bourrelets but without longitudinal markings; colonies may be a foot or more in diameter and 6 inches or more deep.

Transverse sections.—In late ephebic stage of the holotype (diameters 28 by 33 mm.), the tabularium is partially crossed by 41 septa averaging about 2 mm. in length; all septa equally dilated; cardinal and both alar fossulae indicated by shortening of one or more septa and down-warping of tabulae towards all three fossulae; dissepimentarium occupies one-half the radius and consists almost entirely of very large lonsdaleoid dissepiments; septa represented in dissepimentarium by a few long or short septal ridges or crests.

In early ephebic stage of a paratype (diameters 21 by 23 mm.), the tabularium is partially crossed by 35 equally dilated septa, of which those in the cardinal quadrants are about 3 mm. long and the rest are about 2 mm. long; cardinal septum short; cardinal fossula distinct, with three transected tabulae bent down into it; dissepimentarium occupies one-third to slightly less than one-half the radius and consists partly of large lonsdaleoid and partly of small, "broken," somewhat concentric dissepiments; septa in dissepimentarium represented by more or less complete septa and by septal ridges.

In early (?) neanic stage of a paratype (reconstructed diameter about 7 mm.), the dissepimentarium is not quite 1 mm. wide, the septa are 2 mm. or less long and cross the dissepimentarium but do not meet axially. At a diameter of about 10 mm. (reconstructed) the dissepimentarium is not crossed by the septa and is 1 mm. wide.

Longitudinal sections.—The tabulae are generally broadly convex distally and are mostly complete, slightly recurved proximally at their peripheries, and laminated by addition of stereoplasm, 11 or 12 tabulae per cm.; dissepiments of irregular size and shape but steeply inclined to form a very prominent inner wall.

A paratype contains 13 tabulae per cm. in early ephebic regions; tabulae are broadly concave to convex distally; dissepiments small and occupying three-fifths of the radius at a diameter of 16 mm.

Comparison.—This species differs from *Caninia cylindrica* (Scouler), as figured by Salée (1910, pl. 4, fig. 3) chiefly in having more irregular dissepiments, fewer septa, and a sharper boundary between dissepimentarium and tabularium. In earlier stages, this species lacks the prominent dilation of septa in the cardinal quadrants characteristic of *C. cylindrica*.

This species closely resembles *Campophyllum ciliatum* Garwood (1913, p. 561, pl. 48, figs. 6a–c) in transverse section by reason of the large lonsdaleoid dissepiments, short septa, presence of a fossula, and proportional sizes of tabularium and dissepimentarium. It differs from that species in not having paired septa and in having the widely spaced tabulae (as seen in longitudinal section) not interrupted by vesicles. *C. ciliatum* Garwood

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EXPLANATION OF PLATE 46

FIGS. *1–4*—*Caninia tennesseensis* Easton, n. sp. *1*, Transverse section, late ephebic stage, holotype, ×1.5; *2*, transverse section, early ephebic stage, paratype, ×1.5; *3*, transverse section, early neanic stage, paratype, ×3; *4*, longitudinal section, holotype, ×1.5. (p. 277)

5, 6—*Caninia flaccida* Easton, n. sp. *5*, Transverse section, late ephebic stage, holotype, ×1.5; *6*, longitudinal section, holotype, ×1.5. (p. 278)

7–9—*Palaeosmilia compressa* Easton, n. sp. *7*, Portion of surface of holotype, ×1; *8*, longitudinal section of portion of a colony, holotype, ×1.5; *9*, transverse section of portion of holotype with several growth stages represented, ×1.5. (p. 279)

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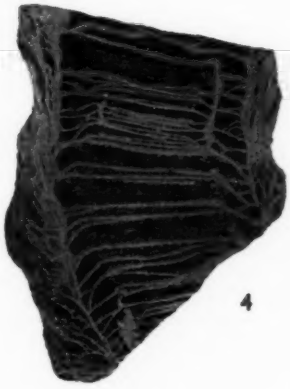
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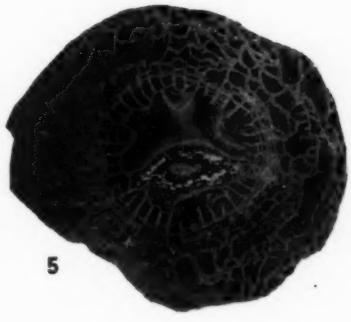
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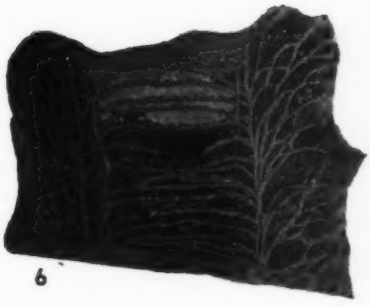
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Easton, Mississippian (Chester) Corals

is from the C_2 of England. It has a fossula and therefore does not fit the genus *Campophyllum*, but seems very likely to be a *Caninia*.

Material.—The holotype, paratypes, and topotypes are in the United States National Museum. Most types may be from one loose colony.

Locality.—These specimens were collected by Charles Butts from the Glen Dean horizon near the middle of the Bangor limestone 200 feet above the base of the west foot of Lookout Mountain, near the standpipe one-quarter mile east of Ft. Payne, Ala. The specimens bear the number 533W which is from Butts' field notebook 121, for the year 1923.

Remarks.—This species belongs to the *Caninia cylindrica* species group, outlined by Lewis (1924, p. 390). Though *C. cylindrica* commonly is included in the genus *Siphonophyllia* in European and some oriental literature, the writer considers this genus to be a junior synonym of *Caninia*. It may be advisable at some future date to refer *Caninia flaccida* to a new genus on the basis of the indication of three fossulae in very mature stages. However, the two extra depressions are not present in middle maturity and are here considered as possible aberrations connected with the alar septa in gerontic stage.

Family PALAEOSMILIIDAE
Genus PALAEOSMILIA Milne-Edwards and Haime, 1848

Diagnosis.—Simple or compound cyathophylloid rugose corals with numerous radially arranged septa; the minor septa may be two-thirds as long as the major septa, which extend almost to the axis. There is a keyhole fossula at the outer part of the tabularium; the tabulae are flattened domes which may sag at the axis, and are typically replaced by tabellae. Dissepiments are numerous, regular, small and globose (Hill, 1940, p. 116).

Genotype.—*Palaeosmilia murchisoni* Milne-Edwards and Haime.

Distribution.—*Palaeosmilia* is known from the Upper Devonian of Belgium and France; from the Lower Carboniferous of many parts of Europe, as well as Russia and China; and from the Namurian of Britain.

Remarks.—Hill (1940, p. 116) considers *Campophyllum* Milne-Edwards and Haime to be a probable junior synonym of *Palaeosmilia*. The writer does not concur. *Strephodes* M'Coy, 1849, is a junior objective synonym, and *Palastraea* (or *Palastrea*) M'Coy, 1851, is considered to be a junior subjective synonym of *Palaeosmilia* by Hill (1940, p. 116). *Clisiophyllites* Löweneck, 1932, and *Strephodes* are considered junior objective synonyms of *Palaeosmilia*, and *Palastraea* is considered a junior subjective synonym of *Palaeosmilia* by Lang, Smith, and Thomas (1940, p. 95). They consider *Kueichouphyllum* Yü, 1931, as a subgenus of *Palaeosmilia* and *Yabeella* Yü, 1931 (not available until 1934), which was proposed as a subgenus of *Kueichouphyllum*, as a junior synonym of *Kueichouphyllum*.

Palastrea carbonaria M'Coy is now generally considered to be conspecific with *Palaeosmilia regia* (Phillips).

PALAEOSMILIA COMPRESSA Easton, n. sp.
Plate 46, figures 7–9

Astraea (Palastrea) carbonaria? McCoy. SAFFORD, *1869*, Geology of Tennessee, pp. 358, 360.

External characters.—Massive plocoid, aphroid corals, apparently periodically rejuvenated and growing by peripheral increase and possibly by lateral increase; calyx irregularly polygonal, with a calicular pit about one-third as deep as the calyx is broad; central part of calicular pit not crossed by septa and forming the deepest part; calicular platform may be slightly raised adjacent to the deep central pit; holotheca thin, readily destroyed by weathering. Holotype about 15 cm. in diameter and 7 cm. thick. Each polyp is separated from the next by a common raised border about 1 mm. high.

Transverse sections.—In ephebic stage (diameters 20 by 25 mm.), there are 36 major septa, which extend within 2 mm. of the center and approach the periphery only at rare instances; minor septa extend to the tabularium but may only enter it as short projections; dissepimentarium occupies one-half to two-thirds of the radius, the inner part being angular but the outer part being lonsdaleoid in pattern (especially in the angles between polyps); fossula obscure, indicated by slight widening of space between two septa near the axis.

In an early ephebic stage (diameters 5 by 6.5 mm.), there are about 11 majors, which extend almost to the central pit; the minors are short and extend only half as far as the majors; there is some indication of lonsdaleoid dissepiments, although most septa reach the periphery.

Longitudinal section.—In the holotype the dissepiments are fine and arch downwards away from the periphery to meet equally fine down-warped edges of the tabulae; tabellae mostly complete, closely spaced, the density being from 42 to 50 tabellae per cm.; tabulae flat or slightly convex downwards.

Comparisons.—This species differs from *P. regia* (Phillips), which it resembles very closely, in being more aphroid, having a zone of condensed dissepiments beneath the external ridge between calyces, and in having mostly complete tabellae. The species differs from *P. murchisoni* in being compound, with many lonsdaleoid dissepiments and without as prominent a fossula.

Material.—The holotype and some topotypes are in the United States National Museum.

Locality.—From the Golconda (?) limestone and shale in the quarry by the railroad at Sherwood, Tenn. The specimens were collected by Charles Butts from a 6-inch to 6-foot shale lying under a limestone carrying *Pentremites* and *Talarocrinus*, and lying over a thin-bedded limestone. This lot of specimens bears the number 533U in Butts' field notebook D, for April, 1919. The section is also given in Butts' notebook 3135B, p. 47.

Remarks.—This is the first true *Palaeosmilia* to be reported from America, since the material described by Heritsch is not *Palaeosmilia*, according to Hill (1940, p. 117). Safford (1869, p. 360) says the coral occurs in bed number 7 of his section between Cowan and the brow of the mountain along the Chattanooga and Sewanee railroad in Franklin County, Tenn.; also "at Crab Orchard, in Cumberland County, and back of Stevenson, Ala."

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MANUSCRIPT RECEIVED BY THE EDITOR JULY 11, 1942.

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 281–288, PLS. 47–49, 3 TEXT FIGS., MAY, 1943

MARINE FAUNA OF THE EASTEND FORMATION OF SASKATCHEWAN

LORIS S. RUSSELL
Royal Ontario Museum of Palaeontology, Toronto, Ontario

ABSTRACT—The discovery of a well-preserved fauna of marine pelecypods in the lower part of the Eastend formation (late Cretaceous) at Eastend, Saskatchewan, permits the first systematic description of fossils from the type section of this formation. The fauna has only a few elements in common with the Eastend fauna from the western part of the Cypress Hills and supports the stratigraphic evidence that the lower Eastend beds of Alberta are represented in Saskatchewan by upper strata of the Bearpaw formation.

A PROJECT grant from the Penrose Bequest of the Geological Society of America made it possible for the writer to spend the field season of 1940 on the plains of western Canada, gathering material for a stratigraphic compilation. A significant result was the discovery of a rich fauna of well-preserved pelecypods in the typical Eastend formation of Saskatchewan. Much assistance in collecting the fossils was given by Messrs. Charles F. and Paul Holmes, of Dollard, Saskatchewan, and the enthusiastic help of the writer's wife, Grace Evelyn Russell, is worthy of special notice. In the laboratory aid was given by Messrs. L. Sternberg and J. Rickett of the Preparatory staff of the Royal Ontario Museum of Palaeontology. Dr. Richard A. McLean of the Academy of Natural Sciences of Philadelphia advised concerning the systematic position of certain specimens.

Of special interest in the stratigraphic work was the determination of the age of the uppermost marine sediments, that is, the dating of the final withdrawal of the sea from the Canadian interior. Particular attention was given to those parts of the section homotaxial with the Fox Hills sandstone of northwestern United States. Within this part of the column lies the Eastend formation of southwestern Saskatchewan and southeastern Alberta.

In its eastern development the Eastend is a rather uniform fine-grained sandstone, but farther west it includes shaly facies in the lower part and coal-bearing beds in the upper. It overlies the marine Bearpaw shale and grades upward into the kaolinized clays of the Whitemud formation, except where the clays have been removed by pre-Lance erosion.

The lower, shaly facies in Alberta has yielded a marine molluscan fauna of very late Pierre or very early Fox Hills age (Landes, 1940). From stratigraphic evidence the writer has concluded that the lower sandstones and shales included within the Eastend formation in Alberta merge eastward into the upper Bearpaw beds, and that the type Eastend of Saskatchewan represents only the upper part of the Alberta development and is to be correlated with the lower part of the type Fox Hills (Russell, 1932). This correlation is corroborated by the evidence afforded by the newly discovered bed of fossils.[1]

The fossils were found in a road cut on Highway 13 about ¾ mile south of the town of Eastend in legal subdivision 12, sec. 30, T. 6, R. 21, west of 3rd meridian. They occur as irregular concentrations in a rather thin zone within a banded series of very fine buff sandstone and dark-brown shale, which has been cracked by slumping, with consequent crushing and distorting of the shells. It is almost impossible to obtain good specimens by the ordinary methods of field collecting. Several large blocks of the fossiliferous layer were bandaged in burlap and plaster and shipped to Toronto for preparation in the laboratory. Unfortunately, some of the blocks were relatively barren and yielded few specimens in proportion to the

[1] Since this paper was written the stratigraphic conclusions of G. M. Furnival (1941) have appeared. This author restricts the term Eastend to the upper part of the Alberta section, placing the lower sandstones and shales in the Bearpaw.

general richness of the bed and the amount of work expended. A better method would have been to work the shells free in the field, strengthening them by one of the modern penetrating and quick-drying cements. The shell substance, though beautifully preserved, is extremely fragile and usually greatly shattered. By hardening with cement and backing one side with plaster, the shell can be removed intact, though the plaster filling has to be retained on one side or the other.

The fossil bed lies just above the middle of a 50-foot outcrop, the top of which is about 50 feet below the base of the kaolinized clays of the Whitemud formation. Though the contact with the underlying Bearpaw shale is not exposed in this vicinity, the fossil bed must lie near the base of the Eastend formation, which is liberally estimated as 100 feet thick in this district.

INTERPRETATION OF THE FAUNA

The new fauna is here referred to as the *Cymbophora gratiae* fauna from the name of the commonest large shell, a new species. This name serves to distinguish it from the only other known fauna of the Eastend formation, that found in the lower shales and sandstones in the western end of the Cypress Hills (Thelma and Medicine Lodge Coulee, Alberta), which has been designated the *Inoceramus fibrosus* fauna by Landes (1940), whose list of identifications follows.

Mollusks from the Eastend formation of southeastern Alberta

Nucula cancellata Meek and Hayden
Nucula planimarginata Meek and Hayden
Yoldia cupressensis Landes
Yoldia mcconnelli Landes
Pteria linguiformis (Evans and Shumard)
Pteria nebrascana (Evans and Shumard)
Inoceramus fibrosus (Meek and Hayden)
Inoceramus sp.
Ostrea glabra Meek and Hayden, var.
Anomia sp.
Thracia? sp.
Pholadomya cupressensis Landes
Tancredia americana cupressensis Landes
Protocardia borealis Whiteaves
Protocardia subquadrata (Evans and Shumard)
Tellina cupressensis Landes
Corbula sp.
Corbula sprouli Warren.
Panope mclearni Warren
Mactra warrenana Meek and Hayden
Mactra sp.
Polinices sp.
Discoscaphites abyssinus (Morton)
Ponteixiles gracilis Warren
Acanthoscaphites quadrangularis (Meek)
Acanthoscaphites sp.

Study of a collection made by the writer at Landes' locality 33 in Medicine Lodge Coulee permits addition of *Laevicardium holmesi* Russell and *Dentalium gracile* Hall and Meek to the above list. This brings the total of forms common to the *Inoceramus fibrosus* and *Cymbophora gratiae* faunas to two or possibly three. The shells identified by Landes as *Corbula sprouli* Warren? may represent the writer's new species *C. spherioides*. *Pholadomya cupressensis* Landes, mentioned and figured in this paper, has not been found in the *C. gratiae* fauna but in a lower horizon, probably upper Bearpaw. The most striking difference between the two faunas is the absence from each of the type species of the other, *Inoceramus fibrosus* and *Cymbophora gratiae*, respectively. As the sediments indicate similar environments for the two faunas, it seems likely that the differences in the constituents indicate a difference in age. The western fauna lies at a greater interval below the Whitemud beds than does the eastern fauna, so it seems impossible that the latter can be older. The alternate interpretation—that the *Cymbophora gratiae* fauna is the younger of the two—supports the writer's previous conclusion (Russell, 1932, p. 133) that the type Eastend of Saskatchewan represents only the upper part of the Eastend formation of southeastern Alberta. A detailed strati-

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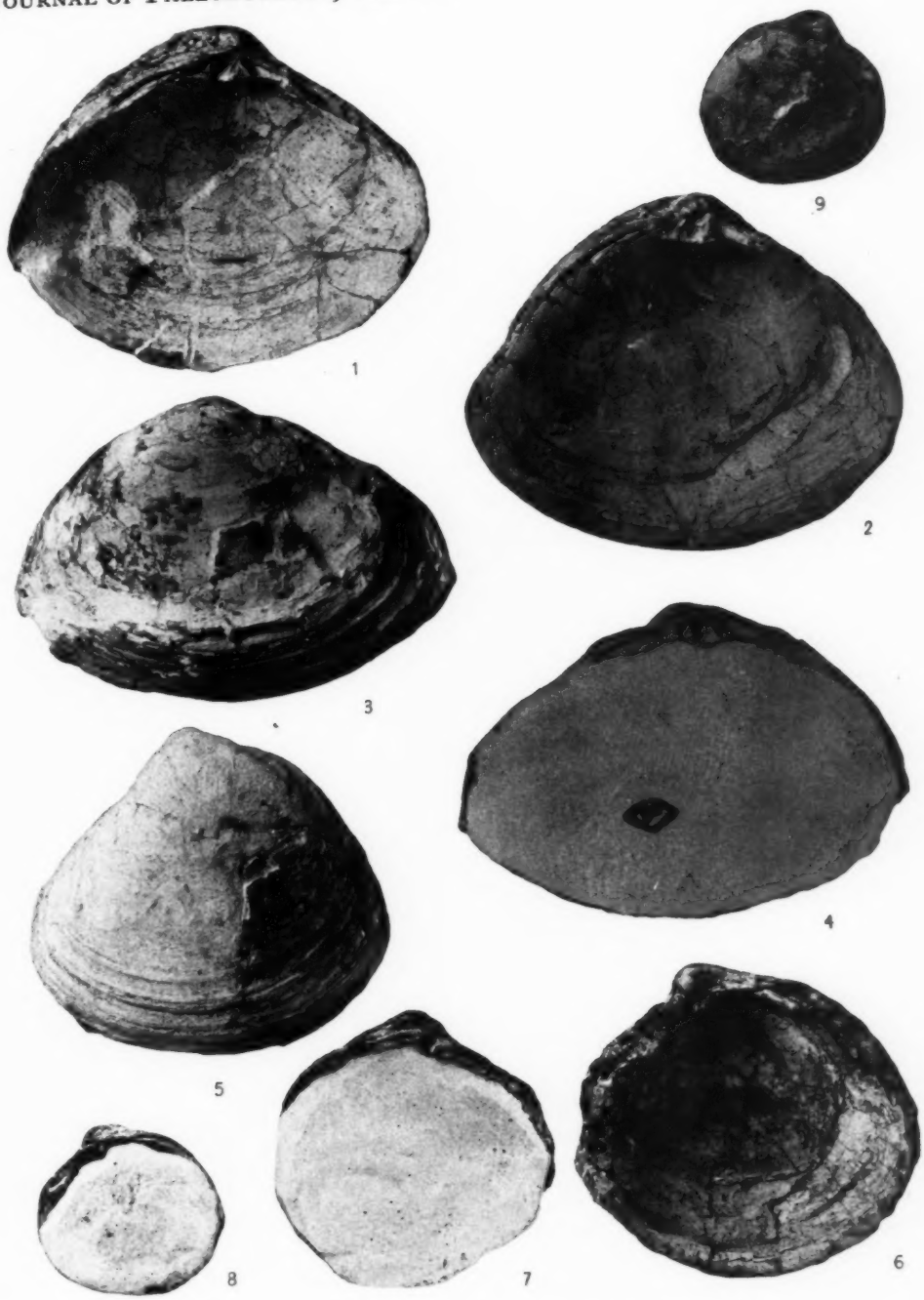
EXPLANATION OF PLATE 47

FIGS. *1–5—Cymbophora gratiae* Russell, n. sp. *1*, Holotype, Royal Ontario Mus. Palaeontology no. 24844, left valve, internal view. *2*, Paratype, no. 24845, left valve, internal view. *3, 4*, Paratype, no. 24846, right valve, external and internal views. *5*, Paratype, no. 24847, left valve, external view. All ×1. (p. 283)

6–9—Laevicardium holmesi Russell, n. sp. *6*, Holotype, Royal Ontario Mus. Palaeontology no. 24848, right valve, internal view. *7*, Paratype, no. 24850, left valve, internal view. *8, 9*, Paratype, no. 24849, right valve, internal and external views. All ×1. (0. 284)



Russell, Late Cretaceous Pelecypods

graphic study of this problem has been made by Dr. G. M. Furnival (1941, 1942) of the Geological Survey of Canada.

Comparison of the *Cymbophora gratiae* fauna with other late Cretaceous marine assemblages does not show much close resemblance. *Gervillia birugata* is probably derived from *G. borealis* of the Bearpaw fauna, and *Tancredia americana cupressensis* is evidently a descendant of *T. americana* of the Pakowki fauna. *Corbula spherioides* has close analogies in the Pakowki and upper Bearpaw. However, the abundant *Cymbophora gratiae* and *Laevicardium holmesi*, as well as the rarer *Saxicava levis*, are not close to any known constituent of the Pakowki and Bearpaw faunas. New faunal elements of this sort seem most likely to have come in from the south, but the listed faunas of the Fox Hills and Cannonball beds (Stanton, 1920) are also devoid of any striking resemblance to the Eastend fauna of southwestern Saskatchewan.

With regard to environment, the Eastend pelecypods occur in the fine-grained sand facies that also contains the lower Pakowki faunas and the fossils in the lower Eastend of Alberta. It contrasts strongly with the shale facies of the upper Pakowki and the Bearpaw faunas. The accumulation of the shells evidently occurred near shore, a conclusion supported by the abundance of carbonaceous matter and fragmentary leaf impressions. From the irregular distribution of the fossils and the abundance of worn fragments, it is thought probable that the shells were washed up along the shore by wave action, probably during a storm.

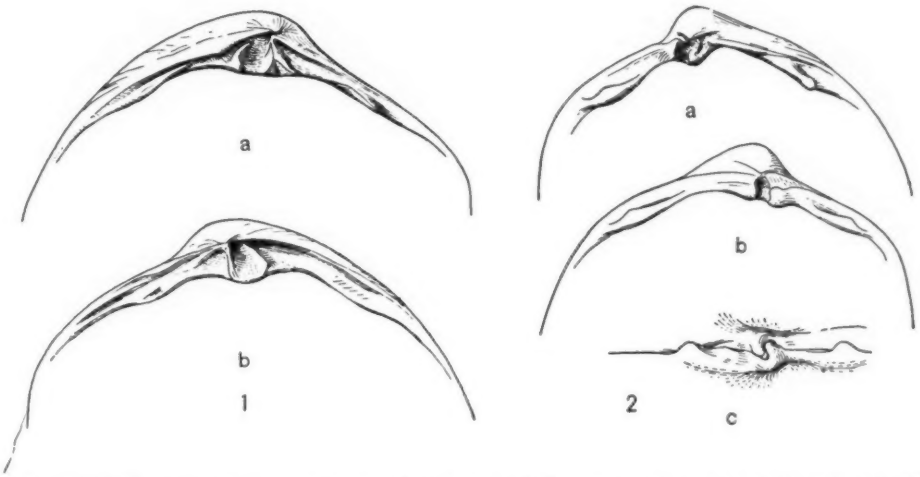


FIG. *1*—*Cymbophora gratiae* Russell, n. sp. Hinge line, slightly restored, ×1. *a*, Left valve; *b*, right valve.
2—*Laevicardium holmesi* Russell, n. sp. Hinge line, slightly restored, ×1. *a*, Right valve; *b*, left valve; *c*, ventral view, both valves in position. (p. 000)

SYSTEMATIC DESCRIPTIONS

Class PELECYPODA
Family MACTRIDAE
Genus CYMBOPHORA Gabb
CYMBOPHORA GRATIAE Russell, n. sp.
Plate 47, figures 1–5; text figure 1

Shell moderately large, equilaterally ovoid; beaks not prominent, slightly inclined forward, placed at about midlength; anterior and posterior dorsal margins sloping about equally, the latter more convex than the former; extremities narrowly rounded; ventral margin broadly and regularly convex; surface marked by irregular concentric lines of growth. Hinge of left valve with strong, smooth laterals and prominent marginal lamellae; anterior cardinal tooth massive, triangular-pyramidal in shape, only slightly excavated ventrally, and extending to ventral margin of hinge plate; chondrophore of moderate size, not

deeply excavated into hinge plate, but concave in shape, due to being bounded in front by the prominent anterior cardinal and behind by a strong, toothlike, oblique lamina, which does not extend to the beak, thus leaving the chondrophore confluent at the apex with the ligament groove. Hinge of right valve with rather weak lateral teeth; anterior cardinal tooth bifid and lambda-shaped, the anterior arm closely appressed to the dorsal margin of the hinge plate, the posterior arm nearly vertical to this margin; chondrophore concave, as on left valve, and similarly bounded behind by a toothlike lamina. Length of holotype, 59.4 mm.; height, 48.4 mm.

Types.—Holotype, no. 24844, Royal Ontario Museum of Palaeontology, from lower Eastend beds south of Eastend, Saskatchewan; paratypes, nos. 24845–24847, same horizon and locality.

Remarks.—This species may be distinguished from other Cretaceous Mactridae either by the relatively large size or by the ovoid outline. "*Mactra*" *formosa* Meek and Hayden (Meek, 1876, p. 207), from the Claggett formation (not the Fox Hills), is very similar in shell form but is smaller and, according to Meek, has a small chondrophore. It is possible that *Cymbophora formosa* is the ancestor of the present species; certainly their environments were very similar.

The characters of *Cymbophora* are not yet fully understood. Dall (1898, p. 879) classified it as a subgenus of *Spisula*, distinguished by the elevated margins of the chondrophore and the open ligament sinus. Gabb's definition (1869, p. 180) laid most emphasis on the concave or "spoon-shaped" chondrophore, which was described as separate from the left anterior cardinal tooth. Gardner (1916, pp. 708–710) described species from the Upper Cretaceous of Maryland that agree closely in hinge characters with the present species. Assuming that the hinge of Gardner's species and the present one are typical of *Cymbophora*, the group is worthy of generic rank, it is distinguished by concave chondrophores with elevated margins, of which the anterior may coincide with the anterior cardinal tooth. The partial separation of the chondrophore and ligament groove suggests close relationships with *Mactra*, whereas the presence of striated laterals in some species recalls the condition in *Spisula*. Probably *Cymbophora* represents an independent Mesozoic development.

The present species is one of the most abundant and striking elements of the Eastend fauna, and, unless the vertical range is greater than at present seems probable, it will serve to designate this particular faunal horizon. The specific name is given in honor of the writer's wife, Grace Evelyn Russell, who assisted in the collection of this material

Family CARDIIDAE
Genus LAEVICARDIUM Swainson
LAEVICARDIUM HOLMESI Russell, n. sp.
Plate 47, figures 6–9; plate 49, figures 7, 8; text figure 2

Shell of medium size, suborbicular in outline, relatively shallow and heavy; no postumbonal ridge; surface marked by faint growth lines and in some specimens by obscure radial markings in the posteroventral region. Hinge of right valve with rather massive lateral teeth, the apices not much produced; anterior lateral with moderate, developed curved buttress from umbonal cavity; posterior lateral with its anterior end crossed by ridge joining ventral margin of hinge plate to posterior lateral lamina; cardinal teeth 2, blunt and heavy, the anterior confluent with the anterodorsal margin of hinge plate and opposing the point of the umbo, the posterior somewhat hook-shaped, curving upward from ventral margin of hinge plate toward anterior cardinal and umbo; socket present between cardinal teeth and behind and above posterior cardinal. Hinge of left valve with laterals much as on right; cardinals heavy and blunt, not as much rotated as on right valve, but lying side by side, separated by a deep socket. Length of holotype, 48.2 mm.; height, 45.5 mm.

Types.—Holotype, no. 24848, Royal Ontario Museum of Palaeontology, from lower Eastend beds south of Eastend, Saskatchewan; paratypes, nos. 24849–24851, same locality and horizon.

Remarks.—In addition to the type occurrence, this species is represented in the lower Eastend of Medicine Lodge Coulee, Alberta, by numerous internal fillings. Using a rub-

ber molding compound, it is possible to reproduce the hinge structure of these specimens in positive form. This shows exactly the same details as the specimens from Eastend and corroborates the reference to *Laevicardium*.

Compared with modern species of *Laevicardium*, *L. holmesi* has a relatively low, shallow shell. The almost complete absence of radial ornamentation and the blunt, heavy nature of the dentition are also atypical. *L. holmesi* might not be a true *Laevicardium*, but it is certainly cardiid and seems to fall closer to this genus than to any other. The shape of shell and the suppression of radial lines can be duplicated in the Miocene to recent *Laevicardium mortoni* (Conrad) of the Atlantic coast, but the size in this species is much smaller than in *L. holmesi*. Authorities differ as to the limits of the genus *Laevicardium*. Some restrict it to Cardiidae with largely suppressed radial sculpture, whereas others include a number of "subgenera" with ornate ribs and spines. Using the restricted interpretation, it appears that species of *Laevicardium* have not been found previously in the Cretaceous of the northwestern interior.

The writer is indebted to Dr. Richard A. McLean, of the Academy of Natural Sciences of Philadeophia, for the generic determination of this species. The specific name is given in honor of Mr. C. F. Holmes, of Dollard, Saskatchewan.

Family TANCREDIIDAE
Genus TANCREDIA Lycett
TANCREDIA AMERICANA CUPRESSENSIS Landes
Plate 48, figures 1–4; text figure 3

Tancredia americana var. *cupressensis* LANDES, *1940*, Canada Geol. Survey Mem. 221, p. 154, pl. 4, fig. 8.

Anterior extremity of shell narrowly rounded but not produced; ventral margin regularly convex; posterior margin vertically truncated, gaping. Hinge characters as in typical *T. americana* (Meek and Hayden). Length of a large plesiotype, 70.7 mm.; height, 47.0 mm.

Types.—Holotype, no. 9356, Geol. Survey Canada, from Eastend beds in Medicine Lodge Coulee, Alberta; plesiotypes, nos. 24841–24843, Royal Ontario Museum of Palaeontology, from Eastend beds south of Eastend, Saskatchewan.

Remarks.—Specimens in the writer's collection show the hinge characters of this subspecies very well, as may be seen from the illustrations. These characters agree very closely with those described by Landes (1940, p. 153) for *T. americana ameriana*.

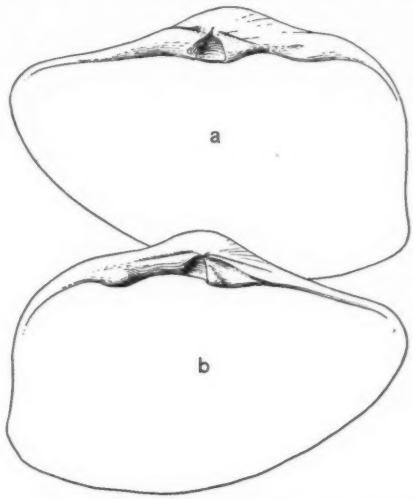


FIG. 3—*Tancredia americana cupressensis* Landes. Hinge line, slightly restored, ×1. *a*, Right valve; *b*, left valve.

The shape of the shell in the present subspecies is, however, quite distinctive. This is one of the few forms common to the western and eastern development of the Eastend fauna.

Family PTERIIDAE
Genus OXYTOMA Meek
OXYTOMA NEBRASCANA (Evans and Shumard), var.?
Plate 48, figure 5

Remarks.—Certain sandstone beds at the fossil locality south of Eastend carry abundant casts and impressions of a very small pteriid, like a miniature of *Oxytoma nebrascana* (Meek, 1876, p. 34). One of the largest specimens measures only 4.0 mm. in length. Apart from the small size, the Eastend shells differ from those of *O. nebrascana*, as known to the writer, in the following characters: The outline is a little less inequilateral; the radiating costulae extend quite to the beak

and show little, if any, evidence of secondary intercalations. Left valves are represented by the dozens, but only three examples of the right valve were obtained. These latter are smooth, as on *O. nebrascana*, but do not appear to have the sharp byssal notch that is the principal generic character of *Oxytoma*. The writer has not decided whether the Eastend shells represent a distinct species, a dwarf variety of *O. nebrascana*, or merely the young of that species. This question might be settled by the discovery of additional material elsewhere, which could establish whether the minute size is a constant feature.

Family PERNIDAE
Genus GERVILLIA Defrance
GERVILLIA BIRUGATA Russell, n. sp.
Plate 49, figure 1

Shell large, beaks nearly terminal, dorsal margin more than half length of shell. Left valve with two distinct, straight ridges, diverging acutely and regularly from beak to posterior extremity; surface between ridges flat, that above and below ridges slightly excavated. Surface marked by fine lines of growth, which cross area between ridges at about right angles to them. Length of type, as preserved, 107.9 mm.; height, 49.1 mm.

Type.—No. 24835, Royal Ontario Museum of Palaeontology, incomplete left valve, from lower Eastend beds south of Eastend, Saskatchewan.

Remarks.—This species was observed to be rather common in the field, but only one good valve was recovered, and even in it the hinge line has been lost through wear. The presence of the two diverging ridges and the flat area between crossed by numerous growth lines give the shells a characteristic appearance, even in the case of fragments. Possibly this is only a variant of *G. borealis* Whiteaves (1885, p. 35), but available specimens of the latter show a poor development of the ridges, especially the lower one, and a tendency for them to be curved.

A species of *Gervillia* occurs in the upper Bearpaw beds in the vicinity of Eastend, but it is not known whether this is *G. borealis* or the present species.

Family PHOLADOMYIDAE
Genus PHOLADOMYA Sowerby
PHOLADOMYA CUPRESSENSIS Landes
Plate 48, figures 6, 7

Pholadomya cupressensis LANDES, *1940*, Canada Geol. Survey Mem. 221, p. 152, pl. 4, figs. 1–3.

Referred specimen.—An almost perfect, uncrushed shell, both valves in position, in the collection of Mr. H. Jones, Eastend, Saskatchewan, from basal Eastend or upper Bearpaw beds northeast of the town; casts in the Royal Ontario Museum of Palaeontology.

Remarks.—This species, rather common in the Eastend beds of Medicine Lodge Coulee, Alberta, is not found in the rich fauna south of Eastend, Saskatchewan. The one specimen from this vicinity was found in a concretion on the old highway about half a mile northeast of the town. Both the elevation and the mode of occurrence suggest that it is from a somewhat lower horizon than that of the *Cymbophora gratiae* fauna. The shell is a little larger than those from Medicine Lodge Coulee. It is beautifully preserved and is here illustrated as a supplement to the type description.

Family SAXICAVIDAE
Genus SAXICAVA Fleuriau de Bellevue

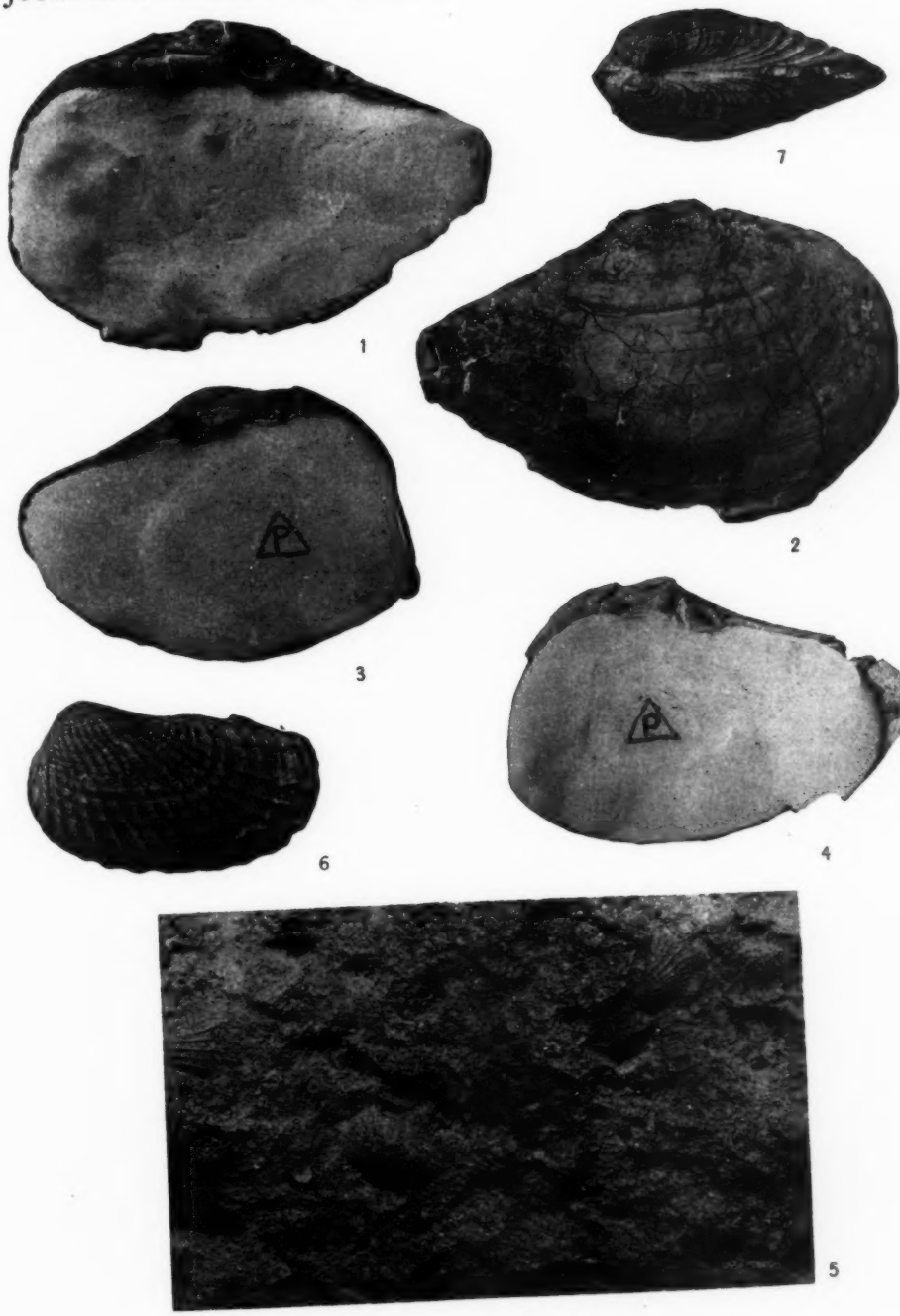
Some authors use the name *Hiatella* for this well-known genus. The question involves dates and interpretations of early works and has been discussed by Dall (1898, p. 833) and by Grant and Gale (1931, p. 427).

EXPLANATION OF PLATE 48

FIGS. *1–4—Tancredia americana cupressensis* Landes. *1, 2*, Plesiotype, Royal Ontario Mus. Palaeontology no. 24841, left valve, internal and external views. *3*, Plesiotype, no. 24842, right valve, internal view. *4*, Plesiotype, no. 24843, left valve, internal view. All ×1. (0. 285)

5—Oxytoma nebrascana (Evans and Shumard), var.? Sandstone slab showing natural casts, Royal Ontario Mus. Palaeontology no. 24830, ×4. (p. 285)

6, 7—Pholadomya cupressensis Landes. Plesiotype, H. Jones collection, External, left lateral and dorsal views, ×1. (p. 286)



Russell, Late Cretaceous Pelecypods

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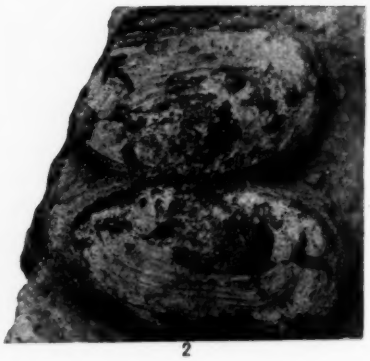

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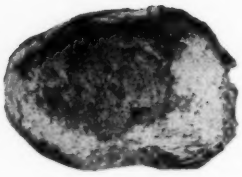

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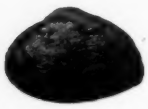

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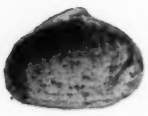

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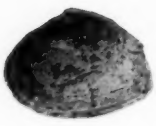

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7

8

Russell, Late Cretaceous Pelecypods

SAXICAVA LEVIS Russell, n. sp.
Plate 49, figures 2, 3

Shell small, ovoid-rectangular, relatively shallow; umbonal sinus and posterior umbonal ridge very faint; anterior margin well rounded; posterior slightly truncated and gaping. Hinge line (right valve only observed) with obscure prominences in front of beak, as in adult *Saxicava arctica*. Length of holotype (left valve), 12.0 mm.; height, 6.6 mm.

Types.—Holotype, no. 24836, Royal Ontario Museum of Palaeontology, both valves, open and somewhat exfoliated; paratypes, nos. 24837–24840; from lower Eastend beds south of Eastend, Saskatchewan.

Remarks.—None of the available specimens is well preserved; hence the generic reference of the species is tentative. It is based on the general size and shape of the shell, the anterior position of the beaks, and the obsolete dentition. The species is characterized by the shallow, rather rounded shell, without pronounced sinus or ridge. There is some variation in the proportions, one specimen being relatively more elongate than the holotype, whereas another is shorter and broader.

Family CORBULIDAE
Genus CORBULA Bruguière
CORBULA SPHERIOIDES Russell, n. sp.
Plate 49, figures 4–6

Shell small, ovoid, nearly equilateral and equivalve; not regularly gibbous from front to rear, but rather flattened about midlength; beaks rounded, not very prominent, especially on left valve; dorsal margins slightly convex, sloping regularly each side of beak; anterior extremity well rounded; ventral margin broadly convex; posteroventral extremity subangular; posterior margin truncated; postumbonal ridge distinct but not sharp. Hinge of right valve with blunt cardinal tooth; of left valve with cartilage pit and toothlike ridge behind, a projecting chondrophore not observed. Surface marked by fine, rather regular, concentric plications and occasional stronger growth lines. Length of holotype, 6.1 mm.; height, 4.3 mm.

Types.—Holotype, no. 24831, Royal Ontario Museum of Palaeontology, a perfect left valve; paratypes, nos. 24832–24834; from lower Eastend beds south of Eastend, Saskatchewan.

Remark.—The shell of this species suggests by its regular, ovoid form a small *Sphaerium* or a *Pisidium*. The hinge line, however, is clearly corbuloid. There are several species of *Corbula* in the Upper Cretaceous of the west that have small equilateral shells. Of these, *C. crassimarginata* Meek and Hayden (Meek, 1876, p. 244) is apparently the closest in shell form to the present species; in fact, the writer suspects that they are identical. Meek and Hayden defined their species mainly on the presence of a thickened ventral margin, but, as they had only one specimen, this may have been an individual growth character. *C. crassimarginata* is from the Fox Hills beds of South Dakota. Another, similar species from the same provenience is *C. inornata* Meek and Hayden (Meek, 1876, p. 245); it is described as having a very inequivalve shell, with a postumbonal groove. Somewhat older geologically is *C. sprouli* Warren (1934, p. 89), from the "Belly River" beds at Outlook, Saskatchewan. The shell of this species is evidently subtrigonal, rather than ovoid, in outline. From a still older horizon, in the Pakowki formation of Alberta, we

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EXPLANATION OF PLATE 49

FIG. *1*—*Gervillia birugata* Russell, n. sp. Holotype, Royal Ontario Mus. Palaeontology no. 24835, left valve, external view, ×1. (p. 286)

2, *3*—*Saxicava levis* Russell, n. sp. *2*, Holotype, Royal Ontario Mus. Palaeontology no. 24836, both valves, external view. *3*, Paratype, no. 24837, right valve, internal view, ×3. (p. 287)

4–6—*Corbula spherioides* Russell, n. sp. *4*, Holotype, Royal Ontario Mus. Palaeontology no. 24831, left valve, external view. *5*, Paratype, no. 24833, left valve, internal view. *6*, Paratype, no. 24834, right valve, internal view, ×3. (p. 287)

7, *8*—*Laevicardium holmesi* Russell, n. sp. *7*, Paratype, Royal Ontario Mus. Palaeontology no. 24851, left valve, external view, ×1. *8*, Paratype, no. 24849, right valve, enlarged view of hinge line, ×3. (p. 284)

have *C. lacteana* Landes (1940, p. 161) whose shell is distinctly subtrigonal, without the truncation of the posterior extremity. The four mentioned species and the present one seem to form a natural group, distinguished by small size and equilateral, subtrigonal to ovoid shells. It is doubtful, however, if they can be separated from *Corbula*, even in the strict sense.

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EOCENE (CAPAY) CORALS FROM CALIFORNIA

HERDIS BENTSON
Standard Oil Company of California, San Francisco, Calif.

CAPAY EOCENE strata at three localities on the west side of the Sacramento Valley have yielded an abundance of corals. In all, a total of 686 specimens have been examined, representing 13 species, of which 6 are new and are here described.

The corals occur in (1) the gray shales exposed in a canyon in the foothills a few miles west-northwest of Winters, Yolo County; (2) in the gritty sandstones and conglomerates in Smith Canyon, type locality of the Capay formation, west of Capay Valley, Yolo County; and (3) in the shales exposed along the east bank of Ualtis Creek, a few miles northwest of Vacaville, Solano County.

The invertebrate faunas from these localities have been assigned to the Capay stage of the California marine Eocene by Merriam and Turner (1937)[1] and are correlative with one another and with faunas from the Cerros shale member of the Lodo formation, north of Coalinga, and from glauconitic shales and sandstones at Marysville Buttes.

The writer wishes to express her thanks to Dr. John W. Wells for his helpful suggestions with regard to the generic assignments of several of these species, and to Dr. J. Wyatt Durham for the photographic work.

LOCALITIES

Winters.—A-1315 = A-1800 = A-3072 = A-3359. In north-south canyon in foothills about 2 miles north of Putah Creek and about 4 miles west-northwest of Winters, Yolo County. Near center of sec. 14, T. 14 N., R. 2 W., in shales on north bank, just above stream bottom, about 75 feet below Pliocene conglomerates.

Smith Canyon.—A-1313. Gritty mudstone locality on south bank of Smith Canyon west of Tancred Station (now abandoned) in Capay Valley, in south central part of sec. 28, T. 11 N., R. 3 W., Yolo County.

A-1314. Yellowish-gray sandstones and conglomerates 10 feet stratigraphically above A-1313.

A-1325. Shells from fossiliferous boulders in sandstones at locality A-1314.

Vacaville.—3573. Shales exposed in steep cliff along bank and in bed of Ualtis Creek, just south of Dunn's Peak, Vaca Valley, Solano County.

A-3356. Gray-green shales from second of three exposures on east bank of Ualtis Creek, sec. 6, T. 6 N., R. 1 W., Napa Quadrangle. From a point 15 feet below top of bank and 55 feet from south end of exposure. Vaca Valley, Solano County.

A-3357. In same exposure, but 3 feet higher and 3 feet farther north than locality A-3356.

Crook & Kirby #23. At foot of slope on east bank of Ualtis Creek 2¼ miles N. 55° W. from center of town of Vacaville, Solano County.

WINTERS LOCALITY

The most abundant representation of corals, both in number of species and in number of individuals, is found at the Winters locality. Eight species, totaling 421 individuals, have been collected.

	Quantity
Flabellum clarki Bentson, n. sp.	16
Trochocyathus imperialis Nomland.	30
Trochocyathus crooki Merriam and Turner.	216
Trochocyathus nomlandi Bentson, n. sp.	82
Trochocyathus (Aplocyathus) durhami Bentson, n. sp.	26
Platytrochus merriami (Nomland).	9
Balanophyllia variabilis Nomland, var.	41
Stephanophyllia californica Nomland.	1

Trochocyathus crooki Merriam and Turner is extremely abundant here but occurs only rarely at Smith Canyon and Vacaville and has not been reported elsewhere. *Balanophyllia variabilis* Nomland, var., is a common form at Winters and Smith Canyon and is well represented at Marysville Buttes. *Trochocyathus imperialis* Nomland and *Platytrochus merriami* (Nomland) were described from the Cerros shale of the Coalinga area. *Trochocyathus imperialis* is fairly abundant at Winters but has not been

[1] The check list given by Merriam and Turner (1937, p. 99–101) represents only a part of the total faunas from these areas.

found at other localities.[2] *Platytrochus merriami* is relatively rare at Winters but is abundant at Vacaville. *Stephanophyllia californica* Nomland is represented by but one specimen at Winters and at Smith Canyon, but several occur in the Vacaville shales. The species was described from the Eocene south of Mt. Diablo. A specimen of *Flabellum* in the Marysville Buttes fauna may represent *F. clarki* Bentson, n. sp., but it is not well enough preserved for positive identification. *Trochocyathus nomlandi* Bentson, n. sp., and *T.* (*Aplocyathus*) *durhami* Bentson, n. sp., are known only from Winters.

It is interesting to note that the total number of corals collected at the Winters locality is almost twice the total number of molluscs. Of mollusks, 258 individuals[3] (191 gastropods, 67 pelecypods) representing 49 gastropod and 7 pelecypod species have been tabulated. The molluscan species most abundant here is *Homalopoma wattsi* (Dickerson), with 27 individuals counted. The ecologic conditions existent at Winters apparently were more favorable to the growth of corals than to other invertebrate types.

The present climatic and bathymetric distribution of the coral genera listed above is, so far as known, as follows: *Flabellum* and *Balanophyllia*, widespread; *Trochocyathus*, chiefly tropical, ranging from 366–549 meters in the Hawaiian Islands (Vaughan, 1919, p. 199); *Stephanophyllia*, complete range not known, but reported also from Hawaii, at depths of 74–366 meters (Vaughan, 1919, p. 199).

The data for interpretation of the ecologic environment under which the Winters coral fauna lived are limited, but the prolific abundance of *Trochocyathus* indicates that conditions favorable to that genus must have existed. Tropical waters and a depth of at least 366 meters seem probable.[4]

[2] The specimen figured by Clark and Woodford (1927, pl. 22, fig. 3, from the Meganos of the Mt. Diablo area) as *Trochocyathus imperialis* does not represent this species.

[3] The figures given throughout this paper are the results of compilations made by the writer during the course of investigation of these northern California Capay faunas. Excluded from the molluscan totals are the scaphopods, present at all three localities, but the fragmentary nature of the material precludes any precise count.

[4] Analyses of these three faunas, based upon ecologic data of the molluscan genera, give similar thermal results, but in each case a much shallower depth.

SMITH CANYON LOCALITY

At Smith Canyon, the coral fauna is comparatively small in number of specimens, with six species and a total of 83 individuals thus far collected.

	Quantity
Madracis wellsi Bentson, n. sp.	66
Trochocyathus crooki Merriam and Turner.	2
Caryophyllia? capayensis Bentson, n. sp.	1
Turbinolia capayensis Bentson, n. sp.	2
Balanophyllia variabilis Nomland, var.	11
Stephanophyllia californica Nomland.	1

Madracis wellsi, *Caryophyllia? capayensis*, and *Turbinolia capayensis* are known only from this area.

In striking contrast to the Winters locality, the number of molluscs at Smith Canyon is more than 15 times as great as the number of corals. A count of 1302 molluscs (1155 gastropods, 73 species; 147 pelecypods, 28 species) has been made by the writer. The most prolific form is *Turritella andersoni* Dickerson (613 individuals), far exceeding in number other species in this fauna.

Turbinolia is found living in the West Indies, and the species *T. corbicula* Pourtales has been collected off Havana at depths of 220 and 310 fathoms (Wells, 1937, p. 5, footnote). *Madracis* is found principally in tropical and subtropical waters, and is living in the Hawaiian Islands at depths of 74–549 meters (Vaughan, 1919, p. 199). *Caryophyllia* and *Balanophyllia* are widespread. Both are reported from Hawaiian waters, *Balanophyllia* at depths of 74—366 meters, *Caryophyllia* from 183–1647 meters (Vaughan, 1919, p. 199). The presence of *Madracis* suggests a habitat in tropical or subtropical waters, with a depth somewhat greater than 74 meters, but probably not exceeding 366 meters, the maximum range for *Balanophyllia*. Apparently the Smith Canyon fauna lived at considerably shallower depths than the Winters fauna but under similar thermal conditions.

VACAVILLE LOCALITY

The Vacaville coral fauna is comprised of five species, totaling 182 individuals. They are as follows:

	Quantity
Platytrochus merriami (Nomland).	130
Trochocyathus crooki Merriam and Turner.	3
Turbinolia n. sp.	36
Stephanophyllia californica Nomland.	12
Stephanophyllia? vacavillensis Palmer.	1

Platytrochus merriami is well represented at Vacaville, but it is necessary to examine a considerable quantity of shale before a specimen is detected. In fact, megafossils are rare in the Vacaville shales, and only 26 molluscs (14 species) have been collected.[5]

Platytrochus has not been included by Gardner and Waugh (1938, p. 202) in their table of the simple Turbinoliidae having species still living. The only reference known to the writer in which the recent distribution of the genus is given is cited by Vaughan (1917, p. 361), from the Australian seas (?).[6] It seems probable that this generic determination is incorrect, but a check cannot be made, as Vaughan did not list the species upon which his citation was based. *Turbinolia*, *Stephanophyllia*, and *Trochocyathus* indicate tropical or subtropical waters, and a depth of around 366 meters, the maximum for *Stephanophyllia*, the minimum for *Trochocyathus* in the Hawaiian Islands.

The ecologic conditions at Vacaville compare with those which obtained at Winters, but other factors must have contributed to account for the sparsity of fossils, both corals and molluscs, in the Vacaville shales.

DISTRIBUTION

The distribution table shows the geographic and stratigraphic occurrence of the species described.

[5] The submegafauna is more prolific. More than 1200 minute gastropods and pelecypods have been obtained by washing and treating the shale samples as is done for foraminifers.

[6] In his Monograph, Vaughan (1900, p. 23) lists *Platytrochus* as "probably extinct."

DESCRIPTION OF SPECIES

Genus FLABELLUM Lesson, 1831

Flabellum LESSON, *1831*, Illustrations de zoologie, pl. 14.

Genotype, *Flabellum pavoninum* Lesson.

FLABELLUM CLARKI Bentson, n. sp.

Plate 51, figures 12, 15

Corallum flabelliform, compressed at base, flaring widely outward toward top; rising above a slender pedicle, the two faces somewhat concave; calyx elongate-ovate in outline, angle of lateral sides varying so that some specimens are more fan-shaped than others; fossula narrow, deep. Primary costae eight or nine in number; distinct but not prominent ridges; spaces between primary costae shallow-concave, crossed by fainter costae of lesser rank. Number of septa not determinable, due to poor preservation of material.

Holotype, UC no. 30441; loc. A-1800;[7] height, 20.9 mm., major axis, 21.2 mm., minor axis, 15 mm.

Occurrence: Winters (16 specimens); one specimen from Marysville Buttes may represent this same species.

Flabellum californicum Vaughan (1900, p. 69, pl. 4, figs. 11, 12) possesses fewer costae and is more flatly compressed; *F. remondianum* Gabb (1864, p. 207, pl. 26, fig. 199) possesses acute alaeform projections at the ends of the longer transverse axis and is more flatly compressed.

Genus CARYOPHYLLIA Lamarck, 1801

Caryophyllia LAMARCK, *1801*, Système des animaux sans vertèbres, p. 370.

Genotype, *Caryophyllia cyathus* Lamarck.

CARYOPHYLLIA? CAPAYENSIS Bentson, n. sp.

Plate 50, figures 4, 8

Corallum simple, with a broad base; elongate, slender, cylindrical pedicle, expanding into a broadly elliptical cup; calyx elliptical, fossula deep. Septa in four cycles; first two cycles prominent, heavy, exsert, first cycle extending to center of calyx, second cycle extends almost to center; third cycle less prominent, extends half the

[7] All specimen and locality numbers refer to collections contained in the Museum of Paleontology, University of California at Berkeley.

distance to center; fourth cycle thin, extending about one-quarter distance toward center. Costae correspond to septal cycles; those opposite first and second cycles most prominently developed; costae opposite fourth septal cycle faint, very fine, dying out approximately one-third distance toward base. Presence or absence of pali not determinable, therefore generic reference must be questioned. Columella fasciculate, composed of twisted processes, not as high as septa.

Corallum simple, costate, basal part small, short, curved in direction of lesser transverse axis, enlarging rapidly into broad calyx with elliptical outline, the longer transverse axis at right angles to direction of curvature of base. Septa in four cycles; first two cycles extend approximately two-thirds radius toward center, broad, thicken outwardly; third cycle extends about two-thirds length of first two cycles, one-half as thick; fourth cycle thin, extending two-thirds length of third cycle.

DISTRIBUTION OF CORALS

	Capay stage					Middle Eocene
	Winters	Smith Canyon (type loc. Capay fm.)	Vacaville shales	Coalinga (Cerros shale)	Marysville Buttes (Marysville fm.)	South side of Mt. Diablo
Flabellum clarki n. sp.	×				×	
Caryophyllia? capayensis n. sp.		×				
Trochocyathus imperialis Nomland	×			×		
Trochocyathus crooki Merriam & Turner	×	×	×			
Trochocyathus nomlandi n. sp.	×					
Trochocyathus (Aplocyathus) durhami n. sp.	×					
Platytrochus merriami (Nomland)	×		×	×		
Madracis wellsi n. sp.		×				
Turbinolia capayensis n. sp.		×				
Turbinolia n. sp.			×			
Balanophyllia variabilis var.	×	×			×	
Stephanophyllia californica Nomland	×	×	×			×
Stephanophyllia? vacavillenis Palmer			×			

Holotype, UC no. 30442; loc. A-1313; height, 13.7 mm., length of major axis, 9 mm.; minor axis, 7.5 mm.

Occurrence: One specimen from Smith Canyon.

Genus TROCHOCYATHUS Milne-Edwards and Haime, 1848

Trochocyathus MILNE-EDWARDS and HAIME, *1848*, Annales des sci. nat. [Zoologie], ser. 3, t. 9, p. 300.

Genotype, *Turbinolia mitrata* Goldfuss.

TROCHOCYATHUS IMPERIALIS Nomland

Plate 50, figurs 9, 15

Trochocyathus imperialis NOMLAND, *1916*, California Univ. Dept. Geol. Sci. Bull., vol. 9, no. 5, p. 63, pl. 4, figs. 11, 12.

Not *Trochocyathus imeprialis* (*sic*) Nomland, CLARK and WOODFORD, *1927*, *idem.*, vol. 17, no. 2, pl. 22, fig. 13.

Lateral faces of septa granulate, granules prominent, rounded, scattered. Pali well developed, entire, free on both edges, inside first two cycles and opposite third cycle (as seen on one well-preserved specimen). Costae 64 in number (according to original description, which checks more or less with specimens with costae sufficiently well preserved to be counted); granular, granules microscopic, scattered irregularly over surface. Costae closely crowded, fine, with five to seven prominently developed on convex side, three fine costae in intervening interspaces. The majority of specimens lack strong ribbing on concave side (in general, side toward which base is curved is concave, but this surface may be flat or even convex), but some individuals possess a few strongly developed costae on this

side of corallum. Columella well developed, composed of lobed processes disposed in a single row (see pl. 50, fig. 9).

Hypotype, UC no. 30443; loc. A-1800; height, 23 mm., length of major axis, 18 mm, minor axis, 14.1 mm.; hypotype, UC no. 30444; loc. A-1800; major axis, 16.1 mm., minor axis, 12.8 mm.

Occurrence: Type from Coalinga area (Cerros shale); Winters (30).

TROCHOCYATHUS CROOKI Merriam and Turner
Plate 50, figures 12–14

Trochocyathus merriami MERRIAM and TURNER, *1937*, California Univ. Dept. Geol. Sci. Bull., vol. 24, no. 6, p. 106, pl. 5, figs. 7–9.

Corallum short, costate, curved obliquely to transverse axis (some individuals do not show the oblique curvature); base small, with small scar of attachment; transverse cross section elliptical. Costae granular, 40 in number, 10 heavier than remainder, a second series of 10 somewhat finer, separated from first series by 20 fine costae; granules rounded, fine, scattered over costae and surface of corallum. Septa thinner than interspaces; first and second cycles fused to columella; third and fourth cycles thinner, extending only part way toward columella; septa granular on lateral faces. Pali indeterminate because of poor preservation of material. Columella vesicular. Thecal wall thin.

Hypotype, UC no. 30445; loc. A-3359; height, 11.3 mm., length of major axis, 8.6 mm., minor axis, 6.6 mm.; hypotype, UC no. 30446; loc. A-3359; height, 15 mm., major axis, 9.4 mm, minor axis, 8.1 mm.

Ocurrence: Winters (216); Vacaville (3); Smith Canyon (2).

Trochocyathus crooki differs from *T. imperialis* in shape; in the latter species, the basal part of the corallum is very short, expanding rapidly into a broad calyx; in *T. crooki*, the basal part is elongate, and upper part of corallum does not become as large. In *T. imperialis*, the number of costae is greater, and the heavy costae are fewer and confined to one side of the corallum.

TROCHOCYATHUS NOMLANDI Bentson, n. sp.
Plate 50, figures 2, 3, 6, 7, 10, 11

Corallum small, simple, cuneiform, almost circular in cross section toward top, narrowing to a compressed cuneate base below middle of corallum; base smooth, free. Costae 48 in number, correspond to septal cycles, extend to base of shell but become faint, fine lines on basal part; costae bear a single row of small, rounded beads extending somewhat below middle of corallum, lacking below; costae opposite first two septal cycles prominent, three finer costae between. Intercostal furrows shallow, narrower than costae. Septa in four cycles; first two cycles prominent, reaching columella, thickened exteriorly; third cycle extends approximately two-thirds distance toward center; fourth cycle thin, fused to third. Septa granulate on lateral faces, granules sharp, pointed, scattered profusely over septal walls. Columella made up of a number of rounded rods, fused with first and second septal cycles. At least one cycle of pali present, with an indication of three cycles seen on one specimen.

Holotype, UC no. 30447; loc. A-1800; height, 4 mm., length of major axis, 5.6 mm., minor axis, 5 mm.; paratype, UC no. 30448; loc. A-1315; height, 4.2 mm., major axis, 5.8 mm., minor axis, 5.3 mm.; paratype, UC no. 30449; loc. A-3359; height, 5 mm., major axis, 7 mm., minor axis, 5 mm.

Occurrence: Found only at Winters (82).

Trochocyathus nomlandi, is distinguished from other described West Coast Eocene species of this genus by its cuneiform shape and smooth, free base. *Trochocyathus? perrini* Dickerson (1913, p. 291, pl. 14, figs. 6a–c) from Marysville Buttes is similar in shape and in ornamentation, but, according to Dickerson, the base is attached by a short pedicle, which has been broken on the type, the only specimen known.

Subgenus APLOCYATHUS d'Orbigny, 1847

Aplocyathus D'ORBIGNY, *1849*, Note sur des polypiers fossiles, p. 5.

Genotype, *Turbinolia armata* Michellotti.

TROCHOCYATHUS (APLOCYATHUS) DURHAMI Bentson, n. sp.
Plate 51, figures 1–3, 6, 7

Corallum simple, short, bowl-shaped, hemispherical, terminated by a very short

peduncle bearing a small scar of attachment; transverse section circular. Calyx circular in outline, shallow. Costae consist of rounded ribs bearing sharp tubercles, large, prominent on costae opposite first and second cycles of septa, extending almost to base; smaller, less prominent on costae opposite third and fourth septal cycles; costae of all cycles continuing to base as fine, faintly indicated ribs. Septa in four cycles, those of first cycle extending slightly more than one-half distance toward center of calyx; remaining cycles decreasingly shorter; septa thickened outwardly, lateral faces granular. Pali forming three coronets, narrow-elongate in shape, developed in inverse ratio to corresponding septal cycle; no pali opposite septa of fourth cycle. Columella well developed, composed of several rods, as seen in cross section. Thecal wall thick.

Holotype, UC no. 30450; loc. A-1800; height, 5.2 mm., length of transverse axes 7.6 mm.; paratype, UC no. 30451; loc. A-3072; height, 6.3 mm., length of axes, 10.6 mm.; paratype, UC no. 30452; loc. A-3359; height, 4 mm., length of axes, 8.7 mm.

Occurrence: Known only from Winters (26).

Dr. John W. Wells, of Ohio State University, who has examined this species, says[8] that:

> It almost certainly is a *Trochocyathus*, and fits in the rare subgenus *Aplocyathus* (type: *T. armatus Michellotti*), hitherto unknown in North America. The species is very close to *T.* (*Aplocyathus*) *obesus* (Micht.) from the Miocene of Turin,—in fact, exactly the same except that the fourth septal cycle is incomplete in this new form. The only living species I know of are two,—one from the South Pacific, *T. hastatus* Bourne, a long-spined form like *armatus*, the other an undescribed species like *obesus*, with four complete cycles, from 766 fms. in the Philippines. This new species from California is the first authentic case of the subgenus, so far as I know, older than lower Oligocene, and is remarkable for its similarity to the Miocene and Recent *obesus* group.

[8] Personal communication, May 17, 1940.

The writer has not seen the original description of *Aplocyathus*, but the *Trochocyathus armatus* (Michellotti), figured by Oppenheim (1903, p. 145, taf. 8, figs. 8, 8a). is very similar in shape and in ornamentation to the California species.

Trochocyathus (*Aplocyathus*) *durhami* can be distinguished readily from other described West Coast *Trochocyathus* species by its bowl shape and short costal spines.

Genus PLATYTROCHUS Milne-Edwards and Haime, 1848

Platytrochus MILNE-EDWARDS and HAIME, *1848*, Mon. des Turbinolides, p. 246.

Genotype, *Turbinolia stokesii* Lea.

PLATYTROCHUS MERRIAMI (Nomland)
Plate 51, figures 8–11

Flabellum? merriami NOMLAND, *1916*, California Univ. Dept. Geol. Sci. Bull., vol. 9, no. 5, p. 62, pl. 3, figs. 1–4; pl. 4, fig. 7.
Trochocyathus merriami, PALMER, *idem.*, vol. 14, no. 8, *1923*, p. 305, pl. 56, figs. 3, 5.

Corallum short, cuneate, bearing no trace of adherence; shape variable in outline, from quadrate with base emarginate or straight to elongate, tapering to form rounded base. Transverse outline elliptical, long axis proportionately greater on quadrate forms than on elongate specimens. Septa occur in four cycles, first two cycles fused to form columella; septa of third

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EXPLANATION OF PLATE 50

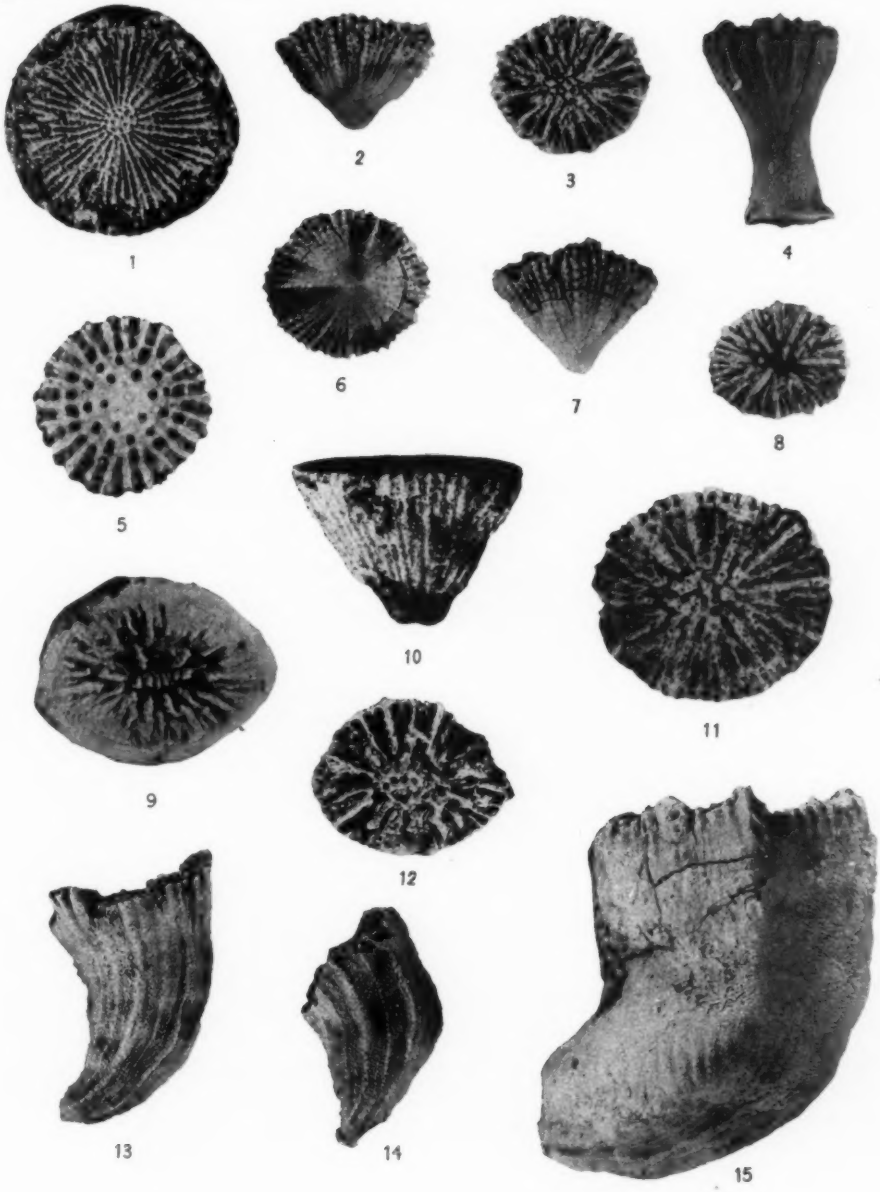
FIGS. *1, 5—Stephanophyllia californica* Nomland. *1*, Hypotype, UC no. 30461, loc. A-1313, ×5.4. *2*, Hypotype, UC no. 30462, loc. A-3356, ×19. (p. 297)

2, 3, 6, 7, 10, 11—Trochocyathus nomlandi Bentson, n. sp. *2, 3*, Holotype, UC no. 30447, loc. A-1800, lateral, calicular views, ×3.9. *6, 7*, Paratype, UC no. 30448, loc. A-1315, ventral, calicular views, ×4. *10, 11*, Paratype, UC no. 30449, loc. A-3359, lateral view, cross section, ×4.5. (p. 293)

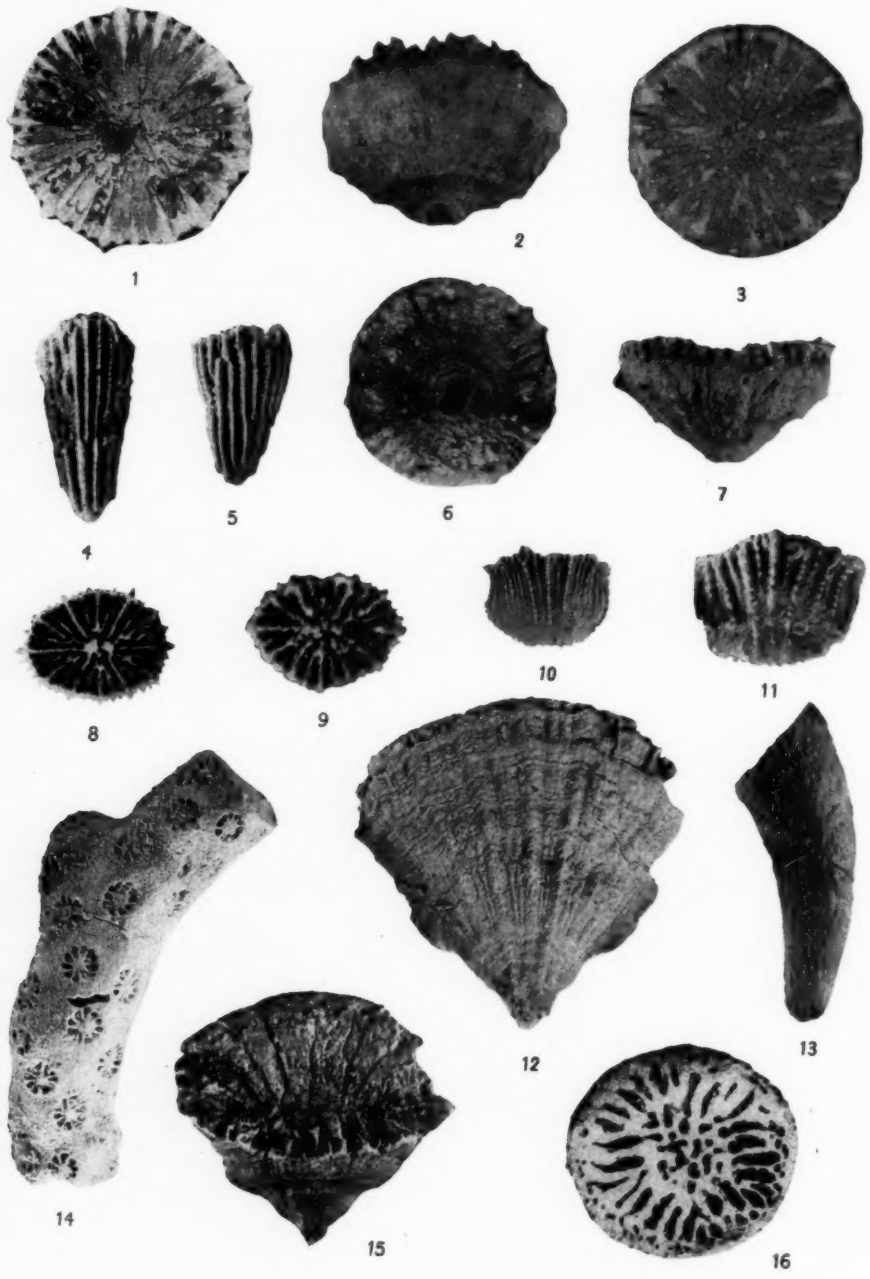
4, 8—Caryophyllia? capayensis Bentson, n. sp. Holotype, UC no. 30442, loc. A-1313, lateral, calicular views, ×2.2. (p. 291)

9, 15—Trochocyathus imperialis Nomland. *9*, Hypotype, UC no. 30444, loc. A-1800, calicular view, ×2. *15*, Hypotype, UC no. 30443, loc. A-1800, lateral view, ×2.8. (p. 292)

12–14—Trochocyathus crooki Merriam and Turner. *12, 14*, Hypotype, UC no. 30445, loc. A-3359, calicular, lateral views, ×3.1. *13*, Hypotype, UC no. 30446, loc. A-3359, lateral view, ×2. (p. 293)



Bentson, Eocene Corals from California



Bentson, Eocene Corals from California

cycle fused to sides of first two; fourth cycle only slightly developed. Surface of septa granulate, granules sharply pointed, numerous. No pali are present. Costae correspond to septa in number, those opposite first and second septal cycles heavier; all costae granular, granules decreasing in size toward base of corallum. Costae corresponding to third and fourth septal cycles die out in middle of corallum, those opposite first and second cycles extend farther down, and in some individuals may reach base. Costae tend to be parallel on quadrate specimens, and curve toward center on elongate individuals. Intercostal furrows shallow, approximately equal in width to costae. Columella false, formed by fusion of lobes from inner margins of the septa of first and second cycles; upper surface of columella papillate, due to rounded appearance of septal lobes. Thecal wall variable in thickness; in quadrate forms, wall thickest at either end of major transverse axis.

The above description is based upon material from the Vacaville locality. The specimens show considerable variation in shape, but "appear to fall within limits of variation of specimens from type locality" (Palmer, p. 305). Nomland's holotype (fig. 1) agrees in outline with quadrate types, his paratype (fig. 3) to the elongate forms. The variability in outline corresponds to that indicated by Vaughan for *Platytrochus goldfussi* (Lea) (Vaughan, 1900, pl. 5, figs. 2–7), with both the elongate tapering form and the quadrate type included within the species.

Hypotype, UC no. 30453; loc. 3573; length of major axis, 4.3 mm., minor axis, 3.3 mm.; hypotype, UC no. 30454; loc. A-3356; height, 2.3 mm., major axis, 3 mm., minor axis, 2.1 mm.; hypotype, UC no. 30455; loc. Crook and Kirby no. 23; height, 3.2 mm., major axis, 4.3 mm., minor axis, 2.7 mm.

Occurrence: Type from Coalinga area (Cerros shale); Winters (9); Vacaville (130).

Genus MADRACIS Milne-Edwards and Haime, 1849

Madracis MILNE-EDWARDS and HAIME, *1849*, Acad. Sci. (Paris) Comptes rendus, t. 29, p. 70.

Genotype, *Madracis asperula* Milne-Edwards and Haime.

MADRACIS WELLSI Bentson, n. sp.
Plate 51, figure 14

Colony branching; branches approximately circular in cross section; surface between calices closely striate longitudinally, entire surface finely granular; calices shallow, may be slightly elevated above general level of corallum, flush with surface, or set in slightly depressed area below surface; elliptical or subcircular in outline; small, diameter averaging about 2.7 mm.; separated by distances of 1 to 2 mm. Septa ten, reaching columella. Columella stout, styliform, terminating in a small tubercle, eroded on most specimens. Parent corallite filled with a deposit predominately dense but spongy in part.

Holotype, UC no. 30456; loc. A-1314; length, 29.6 mm., diameter of branch, 7 mm.

Occurrence: Smith Canyon (66).

Madracis crescentensis Durham (1942, p. 95, pl. 17, figs. 1, 10), from the Crescent formation, Washington, differs from *M. wellsi* in possessing corallites which are smaller, much more numerous, and closer

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EXPLANATION OF PLATE 51

FIGS. *1–3, 6, 7—Trochocyathus (Aplocyathus) durhami* Bentson, n. sp. *1*, Paratype, UC no. 30451, loc. A-3072, cross section, ×3. *2, 6, 7*, Holotype, UC no. 30450 loc. A-1800, oblique view, ×5, ventral, lateral views, ×4. *3*, Paratype, UC no. 30452, loc. A-3359, cross section, ×3.7. (p. 293)

4—Turbinolia capayensis Bentson, n. sp. Holotype, UC no. 30457, loc. A-1325, ×6.7. (p. 296)

5—Turbinolia, n. sp. Hypotype, UC no. 30458, loc. A-3357, ×7.1. (p. 296)

8–11—Platytrochus merriami (Nomland). *8*, Hypotype, UC no. 30453, loc. 3573, cross section, ×4.9. *9, 11*, Hypotype, UC no. 30454, loc. A-3356, cross section, ×7.2, lateral view, ×7.7. *10*, Hypotype, UC no. 30455, loc. Crook & Kirby #23, ×3.9. (p. 294)

12, 15—Flabellum clarki Bentson, n. sp. Holotype, UC no. 30441, loc. A-1800, lateral view, ×2.1, calicular view, ×1.7. (p. 291)

13, 16—Balanophyllia variabilis Nomland, var. *13*, Hypotype, UC no. 30459, loc. A-1313, ×3.5. *16*, Hypotype, UC no. 30460, loc. A-1315, cross section, ×8.5. (p. 296)

14—Madracis wellsi Bentson, n. sp. Holotype, UC no. 30456, loc. A-1314, ×2. (p. 295)

together. In *M. stewarti* Durham (1942, p. 94, pl. 15, fig. 11), also from the Crescent formation, the corallites are much smaller and the surface between them is not striated longitudinally.

Genus TURBINOLIA Lamarck, 1816

Turbinolia LAMARCK, *1816*, Histoire naturelle des animaux sans vertèbres, t. 2, p. 229.

Genotype, *Turbinolia sulcata* Lamarck.

TURBINOLIA CAPAYENSIS Bentson, n. sp.
Plate 51, figure 4

Corallum conical, elongate, slender, calyx circular. Costae 24, prominent, opposite principal septa. Primary costae extend to tip of base; secondaries begin 1.5 mm. above base. Basal part of primaries, below secondary cycle, slightly thickened, edges rounded, a slight serration evident; above, all costal cycles possess serrate upper margins. Intercostal furrows deep, twice width of costae, having double row of pores. Septa 24, corresponding to costae, at least first cycle fused to columella. Specimen is broken off at top, and complete cycle of septa may not be represented. Columella heavy, stellate.

Holotype, UC no. 30457; loc. A-1325; height, 4.2 mm.

Occurrence: One specimen from Smith Canyon. A second small worn specimen of a *Turbinolia* from the same locality may belong to this species, but it is too poor to be specifically identifiable.

Turbinolia capayensis is based upon one poorly preserved specimen, but the crenulated margins of the costae distinguish it from other previously reported West Coast Turbinolias.

TURBINOLIA n. sp.
Plate 51, figure 5

Turbinolia dickersoni Nomland. PALMER, *1923*, California Univ. Dept. Geol. Sci. Bull., vol. 14, no. 8, p. 306, pl. 56, figs. 2, 4.

Corallum conical, elongate, slender. Costae 24 in number (on specimen figured by Palmer, pl. 56, fig. 2), but only 20 on all other specimens examined. Primaries extend to base, secondaries reach nearly to base; tertiaries begin halfway up corallum. Upper margin of costae smooth, entire; primaries and secondaries thickened toward base of corallum; above, cycles equal in weight. Intercostal furrows twice width of costae, ornamented by double row of pores. Septa 20 (number on Palmer's hypotype not determinable), first cycle slightly exsert. Inner margins of first cycle fused to columella, expanding in width at point of fusion; second cycle reaches columella; third cycle only partially developed, fused to sides of septa of first cycle. Columella well developed, stellate.

Hypotype, UC no. 30458; loc. A-3357; height, 3 mm.

Occurrence: Vacaville (36).

Turbinolia n. sp. differs from *T. dickersoni* Nomland (1916, pl. 61, pl. 3, figs. 5–8; Quayle, 1932, p. 98, pl. 6, figs. 1–5, from the Cerros shale) in possessing only three septal cycles, the third cycle incomplete; and the tertiary costae do not extend as far down the corallum as in the latter species. The Vacaville specimens may be immature forms of *T. dickersoni*, in which the fourth costal cycle has not been developed as suggested by Quayle, but of 36 individuals examined, not one possesses more than three costal cycles. For the present, the Vacaville species may be considered distinct.

Genus BALANOPHYLLIA Wood, 1884

Balanophyllia WOOD, *1844*, Annals and Mag. Nat. History, vol. 13, no. 81, p. 11.

Genotype, *Balanophyllia calyculus* Wood.

BALANOPHYLLIA VARIABILIS Nomland, var.
Plate 51, figures 13, 16

Balanophyllia variabilis Nomland, var., MERRIAM and TURNER, *1937*, California Univ. Dept. Geol. Sci. Bull., vol. 24, no. 6, p. 166, pl. 5, figs. 12, 13.

According to Merriam and Turner, the specimens referable to *Balanophyllia variabilis* Nomland, var., are distinguished from *B. variabilis* Nomland (1916, p. 66, pl. 4, figs. 2–4, 13) by their consistently much smaller size and less vesicular thecal walls.

Hypotype, UC no. 30459; loc. A-1313; length, 11.3 mm.; maximum diameter, 4.5 mm.; minimum diameter, 4.1 mm. Hypotype, UC no. 30460; loc. A-1315; maximum diameter, 3.8 mm.; minimum diameter, 3.4 mm.

Occurrence: Winters (41), Smith Canyon (11); abundant at Marysville Buttes.

Genus STEPHANOPHYLLIA Michelin, 1841

Stephanophyllia MICHELIN, *1841*, Dict. sci. nat. Suppl., t. 1, p. 484.

Genotype, *Stephanophyllia elegans* Michelin.

STEPHANOPHYLLIA CALIFORNICA Nomland

Plate 50, figures 1, 5

Stephanophyllia californica NOMLAND, *1916*, California Univ. Dept. Geol. Sci. Bull., vol. 9, no. 5, p. 66, pl. 3, figs. 11–13.
Stephanophyllia californica, PALMER, *1923*, *idem.*, vol. 14, no. 8, p. 304, pl. 56, fig. 1.

Stephanophyllia californica Nomland is described from the Eocene south of Mt. Diablo. Several specimens, chiefly immature, have been collected at Vacaville. The specimens from Smith Canyon and Winters possess only 48 septa, in contrast to 96 in the holotype, but otherwise agree with the original description.

Hypotype, UC no. 30461; loc. A-1313; minimum diameter, 5.1 mm.; maximum diameter, 5.6 mm. Hypotype, UC no. 30462; loc. A-3356; diameter, 1.2 mm.

STEPHANOPHYLLIA? VACAVILLENSIS Palmer

Stephanophyllia? vacavillensis PALMER, *1923*, California Univ. Dept. Geol. Sci. Bull., vol. 14, no. 8, p. 304, pl. 57, figs. 1a–c.

The holotype, from the Vacaville shales, is the only specimen of this species so far recorded. According to Palmer, it is distinguished from *S. californica* Nomland by its ovate outline, projecting center of base, four series of septa, and lack of granulation on septal faces and costal edges.

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JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 298–305, 3 TEXT FIGS., MAY, 1943

A MIOCENE OREODONT FROM JACKSON HOLE, WYOMING

EDWIN H. COLBERT
American Museum of Natural History, New York

ABSTRACT—A well-preserved skull from Jackson Hole has been identified as *Merychyus arenarum* Cope, a characteristic Miocene oreodont. With it was a toe bone of a species of *Oxydactylus*, a lower Miocene camel. The presence of these fossils indicates a new and unsuspected locality for later Tertiary continental sediments in Wyoming.

DURING the summer of 1941 Dr. F. M. Fryxell of Augustana College, Rock Island, Ill. and Dr. Leland Horberg of the University of Illinois were in the Jackson Hole region of Wyoming engaged in geologic field work, as part of a study of the Teton region, made possible by a grant-in-aid from the Penrose Fund of the Geological Society of America. While there they obtained from Mr. Roy A. Saunders of Jackson, Wyo., some fossil mammal remains found by him a few years previously on Pilgrim Creek, which flows into Jackson Lake near its outlet. Drs. Fryxell and Horberg recognized one of these fossils as an oreodont skull, and since this indicated the presence of later Tertiary beds, which hitherto had not been positively identified in this section of the State, they decided, with the permission of Mr. Saunders, to submit the fossils to a vertebrate palaeontologist for a careful identification. Accordingly they conferred with the late Dr. Walter Granger and with Dr. Barnum Brown, and arrangements were made to have the material sent to the American Museum of Natural History, where it was turned over to the present writer for study and identification. The authorities of the Museum are indebted to Mr. Saunders and to Drs. Fryxell and Horberg for making available the materials and information that form the basis of the present paper. The line drawings were made by Miss Marie C. O'Brien. The chart was drawn by Mrs. Elsa Arnoux.

The oreodont, which is represented by the front part of a skull and mandible containing the complete dentition (fig. 1), has been identified as *Merychyus arenarum* Cope. With it (fig. 2) is part of a hind foot of a camel that has been identified as *Oxydactylus* sp.

As *Merychyus* is a characteristic Miocene genus in the sediments of the high plains of western Nebraska and South Dakota and in eastern Wyoming and Colorado, the discovery of a species of it at Jackson Hole is unusually important because it indicates a new and unsuspected locality for later Tertiary continental sediments in Wyoming. The occurrence with it of a species of *Oxydactylus*, a characteristic lower Miocene genus, is confirmatory evidence of its lower Miocene age. The definite identification of Miocene beds in this locality will be of aid, it is hoped, in future interpretations of the stratigraphic and structural history of this region.

Drs. Fryxell and Horberg describe the occurrence of the fossils thus:

> Both specimens were found *in situ* and came from an eroding slope on the northwest bank of the south fork of Pilgrim Creek, one mile above the juncture of this fork with the north fork, and perhaps some 6 or 7 miles upstream from the outlet of Pilgrim Creek into Jackson Lake.
>
> The fossiliferous outcrop is a volcanic tuff belonging to a series of basic flows, breccias, and tuffs exposed along both forks of Pilgrim Creek.
>
> From the canyon forks to a point two miles up the south fork the structure is fairly uniform, strikes varying from N. 20° E. to N. 65° E., dips averaging 45° NW. In this part of the canyon, fine, well-bedded tuffs, white to light gray in color, predominate. Intercalated with them are coarse tuffs, breccias, and dark volcanics, the latter probably flows. Breccias and volcanics are weathered to conspicuous copper green (the "green rock" which has induced local prospecting).
>
> *Section at the juncture of the forks of Pilgrim Creek*
> (Strike, N. 65° E.; dip, 32° W.; thickness estimated)

	Feet
4. Reworked basic volcanics; sandy to conglomeratic; well stratified; cross-bedded channel deposits of breccia; some reworked Pinyon (Eocene) quartzite cobbles.	150
3. Buff sandy tuff; well bedded; irregular concretionary lentils and nodules, which weather in relief. Near base, tuff becomes fine and silty, with white, powdery beds.	50

2. Coarse volcanic conglomerate and sandstone. 20
1. Basic breccia and basalt at base of section.

Two miles up the south fork the canyon is sharply constricted where cut through massive volcanics which form a conspicuous strike ridge. These volcanics are a basic, scoreaceous porphyry, probably flows. They strike N. 20° E. and dip 60°–80° W. Faulting at this point is suggested by the abrupt steepening of dip, shear structure, slickensides, and deformation of cavities in the scoria.

In its several aspects it seems to be particularly close to the type of *Merychyus arēnarum leptorhynchus* as described by Cope. There is good reason to think, however, that Cope's supposed variety is nothing more than an individual variant of *Merychyus arenarum*. As Thorpe has pointed out (1937) it is very possible that the type of *M. arenarum leptorhynchus* is actually a female, to be associated with the somewhat more robust type of *M. arenarum*.

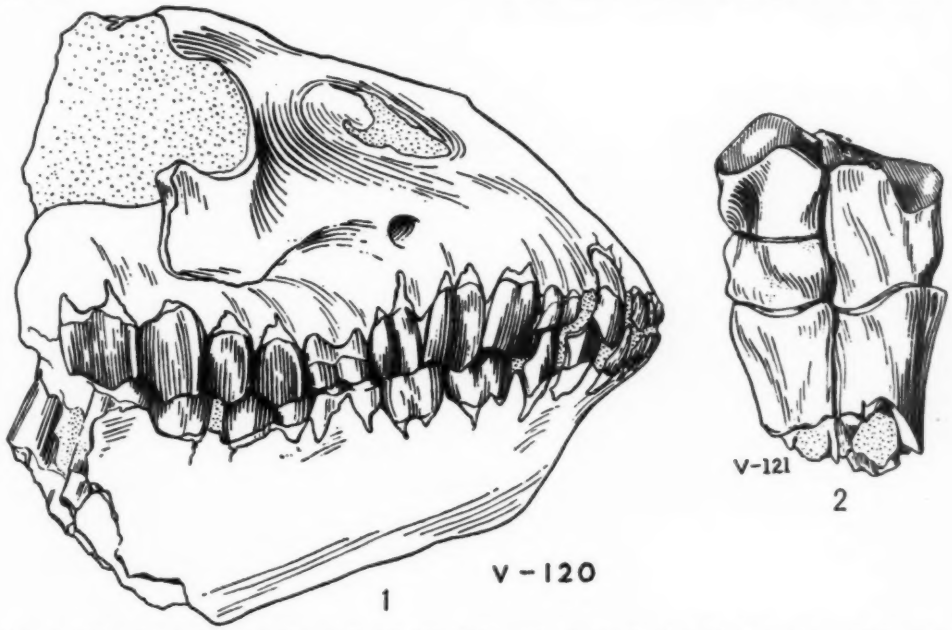

FIG. *1—Merychyus arenarum* Cope. Sp. V-120, Paleontological collection of Augustana College, anterior portion of skull and mandible. Lateral view of right side, ×1.
2—Oxydactylus sp. Sp. V-121, Paleontological collection of Augustana College, part of left pes. Dorsal view, ×1.

The section exposed along Pilgrim Creek is thought to be the equivalent of the late basic breccias of the Yellowstone region, at least in part. As such it represents a transitional facies, in which finer pyroclastics enter into and form the predominant part of the section. The fossils are probably the first vertebrates to be found in the late basic breccias of the Yellowstone region.

The specimen found on Pilgrim Creek in the Jackson Hole region of Wyoming compares closely with various individuals of *Merychyus arenarum* from eastern Wyoming. Because of the close resemblance, there is every reason to think that the present specimen is still another representative of this well-documented species. This suggestion would seem to be a logical one, particularly in view of the fact that *M. arenarum leptorhynchus* is part of a series of specimens showing a certain range of variability, within which it may be included, all coming from one general region in eastern Wyoming.

Be that as it may, the fact is that this present specimen from Jackson Hole is characterized by the small size of its canines and anterior premolar teeth (as is the type of *M. arenarum leptorhynchus*) which would point to the possibility of its being a female individual.

As is characteristic of *Merychyus are-*

narum, the Pilgrim Creek specimen has a rather small, shallow preorbital fossa, containing a small facial or lacrymal vacuity, the lacrymal bone itself is large, the orbit is not raised, and the zygomatic arch is of moderate size. The anterior opening of the infraorbital foramen is situated above the anterior border of the fourth premolar, as in other individuals of this species. The teeth are hypsodont and form a virtual closed series. The anterior upper premolars are directed backward to a certain degree—a feature found in *Merychyus*. The third upper molar is more than twice the length of the first molar; the parastyle and mesostyle of the upper molars are prominent.

TABLE 1

MEASUREMENTS (MILLIMETERS) OF MERYCHYUS ARENARUM

	Pilgrim Cr. Augustana College, V—120	East of Laramie Peak American Museum of Natural History					
		8146	8149	8145	8142	8144	8151
U. cheek teeth length	72		74.4	77.5	85	71	
L. cheek teeth length	77	88	78.3		90.5		77
U. molar ser. length	43	44	44	47	52	43	
L. molar ser. length	44	48	48		55		45.5
U. canine, length	4.8		5.5	8.2	6.0	5.8	
L. canine, length	3.7	6.9	6.0		5.6		3.8
P^{1-4}, length	12.9		14.5	14.5	16.5	14.8	
P_{1-3}, length	10.3	18.1	13.5		14.5		15.1
M^1, length	10.3	12.7	12.2	12.5	12.6	12.0	
M_1, length	9.8	11.5	11.6		12.8		10.5
M^3, length	19	19.5	18.8	20.2	21	18 (est.)	
M^3, height	23		22 (est.)				

The table of measurements compares the specimen from Pilgrim Creek, Wyoming, with the original series of *Merychyus arenarum* described by Cope as from east of Laramie Peak, Wyo. No. 8146 is the type of the species, no. 8145 is the type of the variety *leptorhynchus*.

To check the probablility of the specimen of *Merychyus* from Pilgrim Creek being cospecific with the original series, containing the type specimen of *Merychyus arenarum*, described by Cope as coming from a locality east of Laramie Peak, the method of comparison of a single specimen with a larger sample as elucidated by Simpson and Roe (1939, pp. 188–192) was followed. In the first place, the mean (M) and the standard deviation (σ) for certain measurements of the series of specimens from near Laramie Peak were obtained, the latter according to the formula

$$\sigma' = \sqrt{\frac{\Sigma(d^2)}{N-1}}$$

which has been shown as particularly applicable to small samples. Then the deviations (d) of the corresponding measurements of the Pilgrim Creek specimen from the means of the original series of *M. arenarum* were obtained, and these deviations were divided by the standard deviation (d/σ') to indicate the probability (P) of the single specimen belonging to approximately the same population as the sample. The data are shown in the table of comparison.

The figures for P in the table are based upon the measure of relative deviation for small samples and are obtained from the table of t as presented by Simpson and Roe (1939, p. 206). In this case,

$$t = \frac{d}{\sigma'} = \frac{x - M}{\sqrt{\Sigma(d^2)/(N-1)}}$$

Of the figures in the last column, all but one, namely those for the first upper molar, show that the observed deviations of the Pilgrim Creek specimen from the suite of specimens found near Laramie Peak are likely to be equaled or exceeded in sampling a population of which these several specimens are

constituent elements. The figures for the first upper molar approach significance but are not surely significant.[1] Therefore upon the basis of the numerical data here analyzed, there is good reason to consider the *Merychyus* from Pilgrim Creek as cospecific with *Mercychuys arenarum* as exemplified by the original suite of specimens described by Cope. This quantitative evidence for specific identity between the materials being considered is offered to supplement the qualitative evidence, discussed on preceding pages of the present paper.

TABLE 2

COMPARISON WITH FIVE SPECIMENS OF M. ARENARUM FROM LARAMIE PEAK

Variate	Laramie Peak		Pilgrim Creek			
	M (mm.)	σ	Meas. (mm.)	d	d/σ'	P
U. cheek teeth, length	77	5.96	72	−5	−0.8	>0.10
U. molars, length.....	46	3.66	44	−2	−0.5	>0.10
M^1, length.....	12.4	0.7	10.3	−2.1	−3.0	0.05>0.02
M^3, length.....	19.9	0.94	19	−0.9	−0.96	>0.10
L. cheek teeth, length.....	83.4	6.79	77	−6.4	−0.94	>0.10
L. molars, length.....	49.1	4.09	44	−5.1	−1.24	>0.10
M_1, length.....	11.6	0.94	9.8	−1.8	−1.9	>0.10

It is difficult at this late date to determine exactly the stratigraphic position of the original series of *Merchyus arenarum* (including here the supposed variant, *M. arenarum leptorhynchus*). However the problem may be approached in a somewhat roundabout way, as follows.

Peterson described a supposed subspecies of *Merychyus arenarum*, which he designated *M. arenarum minimus*. This specimen was placed definitely in the Upper Harrison, as it was known at that time. It seems very probable that *M. arenarum minimus*, like *M. arenarum leptorhynchus*, is a small female of *M. arenarum;* indeed, the comparisons are so close between Peterson's specimens and those specimens included in the original series from east of Laramie Peak, that one is led to the conclusion that they all represent members of a single population, and thus are virtually contemporaneous in age.

This being so, the beds along Pilgrim Creek in which *Merychyus arenarum* was found may be regarded as probably correlative either with the top of the lower Miocene (Arikareean) of the Great Plains or with the lower portions of the middle Miocene (Hemingfordian) of the Great Plains. These alternatives are open according to the manner in which the Upper Harrison beds of Peterson are interpreted.

Schultz (1938, p. 443) introduced the name Marsland as representative of the lower portion of the Hemingfordian, to include the Upper Harrison beds of Peterson. Following this procedure, the type of *Merychyus arenarum minimus* would therefore come from the Marsland and would be of Hemingfordian age, and extending the comparison to other areas it would be likely that the beds along Pilgrim Creek might be regarded also as of lower Hemingfordian age.

Recently, however, Cook and Gregory have questioned the propriety of including the typical Upper Harrison of Peterson in the Marsland of lower Hemingfordian age, regarding it rather as a distinct horizon between the characteristic Harrison and the characteristic Marsland.

However, these beds near Marsland, from which the University of Nebraska has obtained a rich and as yet undescribed fauna, are not the "Upper Harrison" beds, but later and distinct from them. The Marsland formation as defined by Schultz included therefore two separable formations, the "Upper Harrison" beds and the higher, previously unnamed deposits east of Marsland. Because of the faunal distinctness of the beds around Marsland from the "Upper Harrison" it seems desirable to restrict the use of the

[1] It has been shown as a result of statistical analysis (see Simpson and Roe) that $P<0.02$ is usually significant, $P>0.02$ but <0.05 is only occasionally significant, while $P>0.05$ is not significant.

term Marsland formation to the deposits of the type locality described by Schultz. (Cook and Gregory, 1941, p. 549.)

Consequently if this viewpoint is accepted, the type of *Merychyus arenarum minimus* would come from the upper portion of the Arikareean, and in like manner the beds along Pilgrim Creek might be regarded as of this same age. The association of the typical Arikareean camel, *Oxydactylus*, with *Merychyus* at the Pilgrim creek locality would seem to lend weight to this latter interpretation.

The foregoing remarks have been based upon the assumption that the series of *Merychyus arenarum* from east of Laramie Peak, Wyo., came from beds that are about contemporaneous with the Upper Harrison of Peterson, in which *Merychyus arenarum minimus* was discovered. This may not be strictly true, even though there is a very close specific identity between the fossils from the two regions. It may be that the beds near Laramie Peak are correlative with the typical Lower Harrison sediments. In a recent letter Mr. Harold J. Cook, who probably has a more thorough knowledge of the Tertiary geology of the region under consideration than any other authority, makes the following observations.

> There are extensive beds "east of Laramie Peak" in Wyoming, which . . . *appear* to be the same sediments and in the same stratigraphic position as the typical "Harrison Beds" (Lower Harrison—grayish beds without the tinting so universally observable in the "Upper Harrison" and later beds). . . . I think . . . almost beyond question that Cope's specimens are of lower Miocene age, but I am not too sure whether they are from the Lower or Upper Harrison.

In the light of this opinion it is quite possible that the beds from along Pilgrim Creek may be correlative with the characteristic (Lower) Harrison, which would make the Pilgrim Creek sediments of Arikareean age, as suggested above, but slightly older than if they were strictly correlative with the beds containing the type of *M. arenarum minimus*.

At this place it may be opportune to consider still further the stratigraphic relationships of the genus *Merychyus*.

On the other side of the Sioux County deposits are the Rosebud beds, containing two species which are rather close in structure to *Merychyus arenarum*, namely *M. curtus* and *M. delicatus*. The exact extent and correlation of the Rosebud sediments have long been subjects of controversy, but it would seem that they are in large part of an approximate Arikareean age. Certainly the presence of *Merychyus* in these deposits offers strong evidence for the close relationship of the Rosebud to the beds of Sioux County, Nebraska, and of Wyoming, which have been discussed above, especially in view of the rather close structural relationships that exist in the several species involved.

All of the species of *Merychyus* so far discussed would seem to be closely related and apparently represent members of closely related faunas of essentially a single age—probably upper Arikareean.

There are, however, three other species of the genus which might be considered here very briefly, since they bear upon the problem being discussed at this place. These are the genotype, *Merchyus elegans*, *M. elegans paniensis*, and *M. pariogonus*. All of these forms have heretofore been recorded as of upper Miocene or Barstovian age.

Merychyus elegans was described by Leidy upon the basis of a specimen found along the Niobrara River "between the mouth of turtle River and a point 300 miles upstream." This form was assigned by Thorpe to the upper Miocene, a logical interpretation since much of Leidy's material from along the Niobrara River was of this age. It would seem very possible, however, that the type of M. *elegans*, evidently coming as it does from far up the Niobrara, may in reality have been contained in beds of lower Miocene age, the relationships of which were not well understood when the specimen was collected.

That such a possibility is well within the range of probability is confirmed by a personal communication from Mr. Cook, as follows.

> I know Matthew decided that the type of Leidy's *M. elegans* must be from the Lower Harrison, near the head of the Niobrara River. In that connection, the bulk of the beds anywhere from near Marsland westward to past the headwaters of the Niobrara River are *entirely* lower Miocene, certainly *not* upper Miocene, and they are principally of Lower Harrison age, save in certain restricted areas which are of Upper Harrison age.

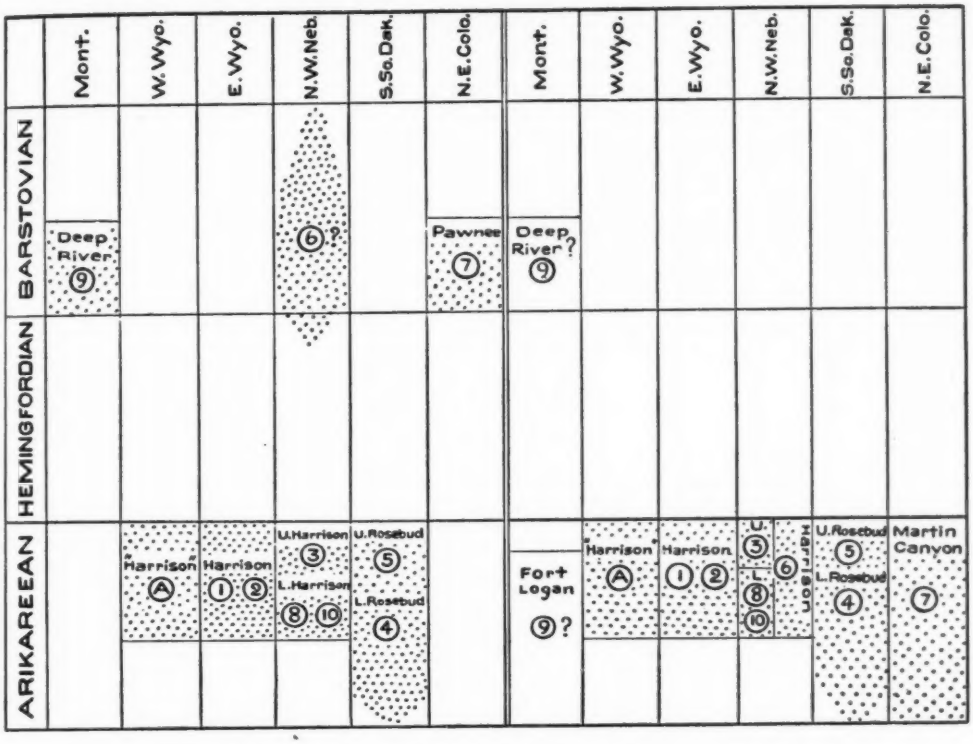

FIG. 3—Two interpretations of the stratigraphic relationships of the species of *Merychyus*. On the left, the stratigraphic occurrence of the various species is shown as based upon the literature to date. On the right, the revised interpretation proposed in this present paper is indicated.

A, *Merychyus arenarum* Cope. Pilgrim Creek, Jackson Hole, Wyoming.
1, *Merychyus arenarum* Cope. Laramie Peak, Wyoming.
2, *Merychyus arenarum leptorhynchus* Cope. Laramie Peak, Wyoming.
3, *Merychyus arenarum minimus* Peterson. Sioux County, Nebraska.
4, *Merychyus curtus* Loomis. Porcupine Creek, South Dakota.
5, *Merychyus delicatus* Loomis. Porcupine Creek, South Dakota.
6, *Merychyus elegans* Leidy. Niobrara River, Nebraska.
7, *Merychyus elegans paniensis* Loomis. Martin's Canyon, Colorado.
8, *Merychyus harrisonensis* Peterson. Vantassel Creek, Wyoming.
9, "*Merychyus*" *pariogonus* Cope. Smith River Valley, Montana.
10, *Merychyus siouxensis* Loomis. Sioux County, Nebraska.

Merychyus elegans paniensis, described by Loomis, was supposed by its author to be of Pawnee Creek age—in other words of upper Miocene affinities. This was based upon Matthew's data, made in 1898, at a time when Matthew had not fully interpreted the interrelationships of the Tertiary beds of northeastern Colorado. It is significant, however, that the locality for the type of this form is Martin's Canyon, in which the deposits are of Martin Canyon, or Arikareean age, rather than of upper Miocene affinities. Consequently there is good reason to think that this form also is of lower Miocene, rather than of upper Miocene age, a conclusion confirmed by conversations with Mr. Charles Falkenbach, who recently visited the Martin Canyon site and with Dr. H. E. Wood, who has been devoting considerable time in recent years to problems of the continental Tertiary of western North America.

This leaves *Merychyus pariogonus* to be considered. This species has been interpreted as having come from the Deep River beds in the region where it was found. It is quite

possible, however, that the type of this species, collected many years ago by one of Cope's field parties, might have come from the Fort Logan beds of Arikareean age, especially in view of the complex geological relationships in this region, which make an interpretation of the stratigraphy difficult, even upon the basis of our modern knowledge of the region. On the other hand, a recent communication from Dr. Harold E. Koerner informs me that two additional jaws of this species, which he collected and recently described (Koerner, 1940, pp. 854–855), came without doubt from the Deep River sediments.

It is quite possible that this form is not a member of the genus *Merychyus*. The type skull is certainly quite different from the characteristic *Merychyus* of the Great Plains, not only as regards its greater size, but also with regard to its different dentition, especially the brachyodont cheek teeth. The problem cannot be definitely solved until more material, especially fossils showing the characters of the premolars, is available.

Consequently, leaving the problem of "*Merychyus*" *pariogonus* in abeyance, it seems very probable that the genus *Merychyus* is an index fossil to the lower portion of the Miocene in North America, specifically to the upper Arikareean and possibly to the lower Hemingfordian. It may be actually limited to one or the other of these levels, according to the manner in which the beds of western Nebraska and eastern Wyoming are interpreted, or it may cover the range of both of them together. At any rate, with these considerations in mind, supported by the evidence of associated *Oxydactylus*, the probabilities of an upper Arikareean age for the beds along Pilgrim Creek in the Jackson Hole region are greatly augmented.

The several interpretations of the stratigraphic relationships of certain beds containing *Merychyus* are presented in the accompanying diagram (fig. 3).

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JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 305–307, PL. 52.

FUNDULUS STERNBERGI, A PLIOCENE FISH FROM KANSAS

GEORGE M. ROBERTSON
Fort Hays Kansas State College, Hays, Kansas

SOME TIME ago George F. Sternberg of the Fort Hays College Museum found specimens of a cyprinodont fish in the diatomaceous marl of northwestern Logan County, Kansas, in the center of the W½ sec. 7, T. 11S, R. 37 W. This horizon is considered to be middle Pliocene (Hibbard and Dunkle, 1942; Wood et al., 1941). The specimens were submitted to Dr. Louis Hussakof of the American Museum of Natural History and were placed by him in the genus *Fundulus*. Two fossil species of this genus had been described previously from rather imperfectly preserved material. After the present paper had been prepared Hibbard and Dunkle (1942) described *Fundulus detillae* from the same horizon.

The fossils from Logan County are in part preserved as impressions, in part as replacement. This makes determination of the number of fin spines or rays difficult, and the numbers stated are subject to possible error. There is also some distortion, especially in body depth. The specimens are flattened, and in some the flattening has crushed structures out of their normal relations. The bones of the skulls are especially distorted and crushed, making identification of separate elements impossible except for such prominent lateral bones as the operculars. The teeth are either located on concealed surfaces or missing on all but one specimen, and on this are well preserved only on the mandible.

FUNDULUS STERNBERGI Robertson, n.sp.
Plate 52

Fundulus sternbergi is a small form. The holotype (pl. 52) has an over-all length of 48 mm., a standard length, from the snout to the last vertebra, of 40 mm. The maximum depth is about one-fourth of the standard length. The depth at the origin of the anal fin, which in these fossils shows less effect of distortion than the maximum depth, is just slightly less than the maximum, i.e. approximately one-fourth of the standard length. The width of the caudal peduncle is one-eighth of the standard length. The predorsal length is five-eighths of the standard length. The head is somewhat distorted, which increases the apparent breadth somewhat. The head length is one-fourth of the standard length. The caudal fin is about one-fourth of the standard length.

The fin rays are difficult to count because some are indicated only by impressions that are not sharply defined. On the holotype the caudal has about 35–37 rays, the dorsal and anal 12, the pectoral 14. The ventral is imperfectly preserved, but the rays appear to have been 6 in number. The origin of the anal is directly beneath that of the dorsal, that of the ventral somewhat posterior and ventral to that of the pectoral.

The scales are obscure over much of the specimen. They are cycloid, showing concentric rings with radiating ridges on the posterior part. There seem to have been 11 or 12 scales in a transverse row from the origin of the anal to the origin of the dorsal. The number in a horizontal row is not accurately determinable but is probably about 40. The head scales are somewhat larger than those on the body.

The details of the head are obscured by crushing. The opercular is preserved mainly as an impression, and its margins are not sharply marked. It seems to be about twice as high as wide. The posterior margin of the preopercular is nearly vertical, as in modern species of *Fundulus*. The subopercular is crushed. A broken fragment of what may have been a palatine bears a tooth. The jaws are so placed as to obscure any teeth they bore. The eye is about 2 mm. in diameter.

The other specimens have about the same proportions as the holotype. The number of rays in the fins may vary slightly, although imperfect preservation makes this difficult to ascertain. The number of vertebrae appears to be 33–35.

One specimen (F.H.K.S.C. no. 27) is incomplete caudally. This specimen shows some teeth on the mandible. They are somewhat under 1 mm. long and are in the form of fine spikes.

Comparison with modern species is unsatisfactory, since specific distinctions in these can not be recognized in the fossils. The other fossil species, except *Fundulus detillae*, are imperfectly known. Comparison with this latter species shows some differences that appear to justify its recognition as a distinct species.

The maximum head length and maximum depth for *F. detillae* are given as more than one-third the total body length. The figure for *F. sternbergi* is less than one-fourth. The origin of the dorsal fin in *F. detillae* is slightly anterior to that of the anal, whereas in *F. sternbergi* it is directly above the anal origin. *F. detillae* is recorded as having four branchiostegal rays, while the holotype of *F. sternbergi* appears to have six.

The holotype of *Fundulus sternbergi* is Fort Hays Kansas State College Museum specimen no. 26. Paratypes are F.H.K.S.C. nos. 27 and 28.

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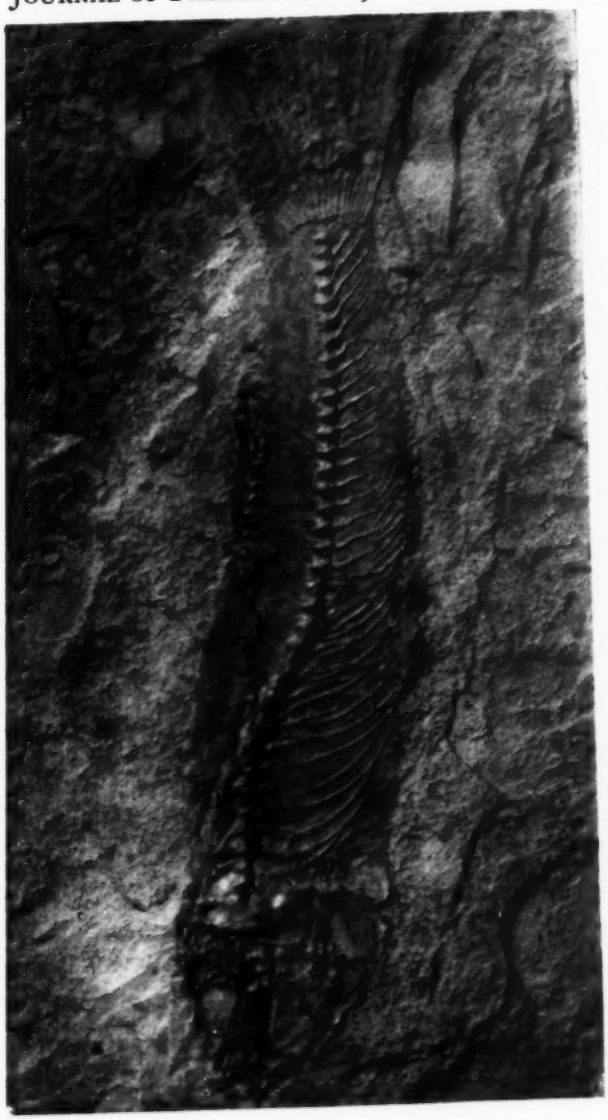
CONTRIBUTION NO. 40 FROM THE DEPARTMENT OF ZOOLOGY OF FORT HAYS KANSAS STATE COLLEGE, HAYS, KANSAS. MANUSCRIPT RECEIVED AUGUST 24, 1942.



Fundulus sternbergi Robertson, n. sp. Holotype, × 3

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 307–309, MAY, 1943

PALEONTOLOGICAL NOTES

CORRECTIONS TO THE KINDERHOOK CONODONT FAUNA, LITTLE ROCKY MOUNTAINS, MONTANA

WILBERT H. HASS
Geological Survey, Washington, D. C.

In 1938 a conodont fauna identified by the author was used as the basis for a brief note (Knechtel and Hass, 1938) which purported to show that rocks of Kinderhook age were present in the Little Rocky Mountains. This fauna was collected by Mr. M. M. Knechtel from a thin unit of dark shale at the base of the Lodgepole limestone of the Madison group. His locality, 8432, is on a tributary of Peoples creek in sec. 5, T. 25 N., R. 24 E., where approximately 5 feet of the conodont-bearing shale are exposed.

Conodonts were treated in that note as authentic teeth and were considered as not being subject to any great amount of specific variation. Also, because most of them differed more or less from named species, it was thought that much of the fauna was new to science. Recently, however, the writer (Hass, 1941) has presented morphological evidence concerning conodonts that leads him to hold: first, that this group of fossils functioned not as ingestive aids, but rather as supports for animal tissues; and secondly, that, owing to an accretionary mode of growth, the external form of any conodont varied greatly during its ontogeny —that is, conodonts are variable entities. These newer concepts necessitate a revision of the Little Rocky Mountain fauna, and the one presented below, it is believed, is a truer representation of the assemblage actually present in the basal shale of the Lodgepole limestone. Though the revision has greatly reduced the number of species, it has not in any way vitiated the primary conclusion reached in 1938, namely, the Kinderhook age of the stratigraphic horizon involved. Rather, the revision tends to strengthen this conclusion. No material in addition to that used in 1938 was available for this study.

It should be noted that, whereas in 1938 46 species were thought to be new, the revised listing shows all complete forms as identified or compared with previously described ones. Some of the species in the revised list include forms that would have been separated into several categories had not the effects of suppression and rejuvenation of parts and the stages of the ontogeny reached by the various individuals been taken into into account.

A Kinderhook age for the Little Rocky Mountain fauna is suggested by two kinds of evidence: the presence in it of so-called diagnostic genera; and a faunal similarity with certain Kinderhook formations. Since 1934 Branson and Mehl have championed the idea that certain conodont genera are diagnostic of the Devonian, whereas others are equally indicative of the Lower Mississippian. These two sets of genera, they hold, are exclusive of each other in pure faunas, being found commingled only as a result of stratigraphic admixing (Branson and Mehl, 1941). If one accepts these propositions, then the Little Rocky Mountain fauna is a correlate of the Kinderhook into which a Devonian element has been introduced. This follows from the fact that the fauna in question contains several diagnostic genera, three of which, *Pseudopolygnathus*, *Siphonognathus*, and *Solenognathus* are indicative of the Lower Mississippian of Branson and Mehl and one, *Palmatolepis*, of their Devoniam.

More conclusive than the evidence presented by the so–called diagnostic genera is the fact that most of the species in the Little Rocky Mountain fauna, can be identified or compared with those in Kinderhook faunas of post-Chattanoogan age. The accompanying faunal chart bears this out. Nine species are listed (Branson, 1934) in common with the Hannibal shale of Missouri, 12 with the Bushberg sandstone member of the Sulphur Springs formation of Missouri (Branson and Mehl, 1934), and 12 with a Bushberg-Hannibal horizon located near Ada, Oklahoma (Cooper, 1939). The upper New Albany shale

DISTRIBUTION OF THE LITTLE ROCKY MOUNTAIN CONODONTS

Revised name	Oklahoma	Missouri				Indiana	Knechtel and Hass, 1938
	Bushberg-Hannibal horizon	Bushberg	Hannibal	Chouteau	Grassy Creek	Upper part New Albany shale	
Bryantodus cf. *B. macer* Branson & Mehl	×	×					*Bryantodus*, 2 n. sp.
Bryantodus sp., fragments							*Bryantodus*, n. sp. *Ozarkodina*, n. sp.
Dinodus fragosus (E. R. Branson)	×		×				*Palmatodella fragosa* E. R. Branson.
Hindeodella cf. *H. delicatula* Branson & Mehl	×	×					*Hindeodella*, 2 n. sp.
Hindeodella sp., fragments							*Hindeodella*, 2 n. sp.
Ligonodina cf. *L.* sp. of E. R. Branson			×				*Ligonodina*, n. sp.
Ligonodina cf. *L.* sp. of Branson & Mehl		×					*Ligonodina*, n. sp.
Palmatolepis rugosa Branson & Mehl					×		*Palmatolepis* aff. *P. rugosa* Branson & Mehl. *Palmatolepis* sp., fragments of several species.
Polygnathus communis Branson & Mehl	×	×	×	×			*Polygnathus* aff. *P. communis* Branson & Mehl.
Polygnathus inornata E. R. Branson	×	×	×	×			*Polygnathus inornata* E. R. Branson. *Polygnathus*, 2 n. sp.
Polygnathus longpostica Branson & Mehl	×	×	×				*Polygnathus*, 5 n. sp.
Prioniodus cf. *P. alatus* Hinde	×					×	*Prioniodus*, n. sp.
Prioniodus sp., fragments							*Prioniodus*, 6 n. sp.
Pseudopolygnathus prima Branson & Mehl	×	×	×				*Pseudopolygnathus* cf. *P. asymmetrica* E. R. Branson. *Pseudopolygnathus*, 13 n. sp.
Siphonognathus duplicata Branson & Mehl	×	×	×	×		×	*Siphonognathus duplicata* Branson & Mehl.
Siphonognathus quadruplicata Branson & Mehl	×	×	×			×	*Siphonognathus quadruplicata* Branson & Mehl.
Siphonognathus sexplicata Branson & Mehl	×	×				×	*Siphonognathus*, n. sp.
Solenognathus sp., fragments							*Solenognathus*, 2 n. sp.
Spathognathodus sulciferus (Branson & Mehl)	×	×	×				*Spathodus*, 5 n. sp.
Synprioniodina? delicatula Branson & Mehl		×					*Synprioniodina*, n. sp.
Trichognathus sp., fragments							*Trichognathus*, fragments of several species.

of Indiana (Huddle, 1934) is represented by four species, and the Chouteau (Branson and Mehl, 1938) and Grassy Creek (Branson and Mehl 1933) formations of Missouri by three and one species respectively. To some the presence of *Prioniodus* cf. *P. alatus* and *Palmatolepis rugosa* in the Little Rocky Mountain fauna would suggest stratigraphic admixing. But, inasmuch as it is quite possible that the vertical ranges of conodont species may be greater than that which is now accorded them, the writer does not consider the presence of any species in the fauna under discussion as being anomalous.

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TRYONELLA, NEW NAME FOR TRYONIA STEPHENSON, 1941

LLOYD WILLIAM STEPHENSON
U. S. Geological Survey, Washington, D. C.

As the name *Tryonia* Stephenson (1941), proposed for a new genus of Gastropoda, is preoccupied by *Tryonia* Stimpson (1865), the name *Tryonella* is here designated as a substitute. *Tryonia valida* Stephenson, the genotype of *Tryonia* Stephenson, now becomes *Tryonella valida* (Stephenson), the genotype of *Tryonella*.

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RAFINESQUINA SINCLAIRI, NEW NAME FOR R. ELONGATA SALMON

ELEANOR S. SALMON

In a recent number of the Journal of Paleontology (vol. 16, no. 5, p. 576, Sept. 1942) I used the name *Rafinesquina elongata* for a new species of brachiopod from the Guttenberg at Milbrig, Illinois. It has been kindly pointed out to me by G. Winston Sinclair of Sir George Williams College, Montreal, that this name had previously been used by Teichert (Meddeleser om Grønland, Bd. 119, Nr. 1, p. 29, 1937) for a new species from the Ordovician of North Greenland. Accordingly, I propose to rename the species described by me *Rafinesquina sinclairi*.

FOSSIL VERTEBRATES FROM EL SALVADOR

R. A. STIRTON and WILLIAM K. GEALEY
University of California, Berkeley, California

A Pleistocene vertebrate fauna was discovered recently in eastern El Salvador, Central America, by a University of California expedition. The fossils were embedded in a thin poorly consolidated stratum of andesitic stream conglomerate overlying clays of deeply weathered volcanic bedrock. This stream fill is somewhat elevated above and isolated from the present drainage.

Most of the bones are those of the giant ground sloth *Megatherium*. Other mammals represented in the collection are *Smilodon*, *Bison*, and a notoungulate. This marks the southernmost recorded range of the bison (unless *Ovis? scaphoceras* Cope, 1894, from Nicaragua is a bison) and the northernmost dispersal of notoungulates onto the North American continent. The bones are only partly replaced, suggesting a late Pleistocene age for the fauna. The quarry was discovered while carrying out a geological survey of El Salvador under a project of the Geological Society of America.

MANUSCRIPT RECEIVED BY THE EDITOR JULY 21, 1942.

ILLUSTRATED CATALOGUE OF NORTH AMERICAN DEVONIAN FOSSILS

Two new sections of the card catalogue of North American Devonian fossils, prepared under the direction of a committee of the Paleontological Society, are now ready for subscribers. They cover the Conocardiidae (34 cards, by C. C. Branson) and the Leperditacea (19 cards, by A. S. Warthin, Jr.). This instalment of the catalogue is priced at $2.85 plus postage and is obtainable from the publisher, the Wagner Free Institute of Science, Montgomery Avenue and Seventeenth Street, Philadelphia, Pa.

Copies of the five sections previously issued may still be obtained from the publisher.

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 3, PP. 310–321, MAY, 1943

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*COLBERT, EDWIN H., American Museum of Natural History, New York, N. Y.
*COLE, W. S., Orton Hall, Ohio State University, Columbus, Ohio.
COLLINS, R. LEE, Dept. of Geology, University of Tennessee, Knoxville, Tenn.
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*COOKE, C. WYTHE, U. S. Geological Survey, Washington, D. C.
COOLEY, MARY ELIZABETH, 703 Forest Ave., Ann Arbor, Mich.
COOPER, CHALMER LEWIS, Illinois Geological Survey, Urbana, Ill.
*COOPER, G. ARTHUR, U. S. National Museum, Washington, D. C.
CORDELL, ROBERT JAMES, 7 Allen Place, Columbia, Mo.
*CORYELL, HORACE N., Dept. of Geology, Columbia University, New York, N. Y.
CRAIG, LAWRENCE CAREY, Elizabethton, Tenn.
*CRAM, IRA H., 35 E. Wacker Drive, Chicago, Ill.
*CRONEIS, CAREY G., Walker Museum, University of Chicago, Chicago, Ill.
CULBERTSON, JOHN ARCHER, Continental Oil Co., 610 Oil & Gas Bldg., Houston, Tex.
CULLISON, JAMES, Missouri School of Mines, Rolla, Mo.
*CUMINGS, EDGAR R., Indiana University, Bloomington, Ind.
*CUSHMAN, JOSEPH A., 76 Brook Road, Sharon, Mass.

*DECKER, CHARLES E., Faculty Exchange, University of Oklahoma, Norman, Okla.
*DEISS, C. F., Dept. of Geology, Montana State University, Missoula, Mont.
DENISON, ROBERT HOWLAND, Dartmouth College Museum, Hanover, N. H.
DENSON, NORMAN MACLAREN, Dept. of Geology, Princeton Univ., Princeton, N. J.
*DICKERSON, ROY E., 1305 N. Adams St., Arlington, Va.
*DORF, ERLING, Dept. of Geology, Princeton University, Princeton, N. J.
DRIVER, HERSCHEL L., 630 West Palm Drive, Glendale, Calif.
DU BOIS, ERNEST PAUL, Illinois Geological Survey, Urbana, Ill.
DUCKWORTH, ALBERT STONE, 915 College Hill, Cape Girardeau, Mo.
DUDLEY, RUTH MARY, Dept. of Geology, Univ. of Wisconsin, Madison, Wis.
*DUNBAR, CARL O., Peabody Museum, Yale University, New Haven, Conn.
DUNCAN, DONALD CAVE, U. S. Geological Survey, Washington, D. C.
DUNCAN, HELEN, U. S. Geological Survey, Washington, D. C.
DUNN, P. H., Mississippi State College, Miss.
DURHAM, J. WYATT, Dept. of Paleontology, Univ. of Calif., Berkeley, Calif.

EASTON, WM. HEYDEN, State Geological Survey, Urbana, Ill.
*EDWARDS, IRA, Public Museum, Milwaukee, Wis.
EFFINGER, WILLIAM LLOYD, P.O. Box 44, Tallahassee, Fla.
EHLERS, GEORGE M., University of Michigan, Ann Arbor, Mich.
*ELIAS, M. K., c/o Conservation & Survey Division, Univ. of Nebraska, Lincoln, Neb.
ELLER, E. R., Carnegie Museum, Pittsburgh, Pa.
ELLIS, BROOKS FLEMING, 72 Clarendon Road, Scarsdale, N. Y.
ELLISON, SAMUEL, P., JR., School of Mines & Metallurgy, Rolla, Mo.
*ELLISOR, ALVA C., Humble Oil & Refining Co., Drawer D., Houston, Tex.
ENDO, RIUJI, The Central National Museum of Manchoukuo, Hsinking, Manchoukuo.
EVANS, CHARLES S., Union Gas Co. of Canada, Chatham, Ont., Canada.

FALKENBACH, CHARLES HENRY, Frick Laboratories, American Museum of Natural History, New York, N. Y.
FANSHAWE, JOHN RICHARDSON, Ohio Oil Co., Findlay, Ohio.
FAUL, HENRY, National Research Corp., 100 Brookline Ave., Boston, Mass.
FIENNING, ROBERT L., 1011 South Eighth St., Richmond, Ind.
FISCHER, ALFRED GEORGE, Dept. of Geology, Virginia Polytechnic Institute, Blacksburg, Va.
FLOWER, ROUSSEAU H., Dept. of Geology, University of Cincinnati, Cincinnati, Ohio.
*FOHS, F. JULIUS, Fohs Oil Co., 1340 Mellie Esperson Bldg., Houston, Tex.
FOX, STEVEN KNOWLTON, JR., Dept. of Geology, Princeton University, Princeton, N. J.
FREEMAN, MRS. LOUISE BARTON, Box 680, Lexington, Ky.
*FRICK, CHILDS American Museum of Natural History New York N. Y.
*FRITZ, MADELEINE ALBERTA, 388 Brunswick Ave., Toronto, Ont., Canada.
FRIZZELL, DONALD LESLIE, International Petroleum Co., Ltd., Negritos, Peru.
FRY, WILLIAM WILLCOX, 148 Carroll St., St. Louis, Mo.
*FURLONG, EUSTACE L., California Institute of Technology, Pasadena, Calif.
FURNISH, WILLIAM M., Shell Oil Co., Inc., Box 2037, Tyler, Tex.

GALE, HOYT RODNEY, 1775 Hill Drive, Eagle Rock, Los Angeles, Calif.
*GALLOWAY, J. J., Indiana University, Bloomington, Ind.
*GARDNER, JULIA A., U. S. Geological Survey, Washington, D. C.
GARRETT, MRS. EUNICE PETERSON, 336 N. Princeton Ave., Swarthmore, Pa.
*GAZIN, 1ST. LT. CHARLES LEWIS, Box 431, Harrisburg, Pa.
GEIS, HAROLD L., Atlantic Refining Co., Edificio La Metropolitana 401, Habana, Cuba.
GILBOE, JOHN DANIEL, Box 999, Bakersfield, Calif.
GILDERSLEEVE, BENJAMIN, 153 Spence Place, Knoxville, Tenn.
*GILMORE, C. W., U. S. National Museum, Washington, D. C.
*GOLDRING, WINIFRED, New York State Museum, Albany, N. Y.
*GORDON, CLARENCE E., Massachusetts State College, Amherst, Mass.
GORDON, MACKENZIE, JR., Box 59 Route 1, Los Altos, Calif.
GRAHAM, JOSEPH J., 6650 Dana Street, Oakland, Calif.
*GRANT, U. S., IV, University of California, Los Angeles, Calif.
GREACEN, KATHERINE FIELDING, Milwaukee-Downer College, Milwaukee, Wis.
*GREENE, F. C., Biltmore Arms Apt., 900 E. 9th St., Kansas City, Mo.
GREGORY, JOSEPH TRACY, University of Michigan, Ann Arbor, Mich.
*GREGORY, W. K., American Museum of Natural History, New York, N. Y.
GRIES, JOHN PAUL, Dept. of Geology, South Dakota School of Mines, Rapid City, S. D.
GRILEY, H. L., Sun Oil Co., 1608 Walnut St., Philadelphia, Pa.
GROSSMAN, WILLIAM LEWIS, c/o Mrs. W. L. Grossman, Andover, N. Y.
GROVE, BRANDON H., Producing Dept., Socony Vacuum Oil Co., Room 1700, 26 Broadway, New York, N. Y.
*GURLEY, W. F. E. R., 6151 University Ave., Chicago, Ill.
GUTSCHICK, RAYMOND C., Dept. of Geology, University of Illinois, Urbana, Ill.

HAAS, OTTO H., The American Museum of Natural History, New York, N. Y.
HADLEY, WADE HAMPTON, JR., Pure Oil Co., Room 1616, Canal Bldg., New Orelans, La.
HAGAN, WALLACE W., 5902½ Beechwood Ave., Indianapolis, Ind.
*HANNA, G DALLAS, California Academy of Sciences, San Francisco, Calif.
*HANNA, M. A., Gulf Production Co. of Texas, Houston, Tex.
HARBISON, ANNE, The Barclay, Rittenhouse Square, Philadelphia, Pa.
HARLTON, BRUCE H., The Amerada Petr. Corp., Drawer 2040, Tulsa, Okla.
*HARRIS, GILBERT D., 126 Kelvin Place, Ithaca, N. Y.
*HARTNAGEL, CHRIS A., New York State Museum, Albany, N. Y.
*HAYNES, WINTHROP P., Rm. 2150, 30 Rockefeller Plaza, New York, N. Y.
HAZZARD, JOHN CHARLES, Union Oil Co. of Calif., 617 W. 7th St., Los Angeles, Calif.

*HEDBERG, HOLLIS D., Mene Grande Oil Co., Apartado 45, Barcelona, Venezuela, S. A.
HEMINWAY, CAROLINE ELLA, Smith College, Northampton, Mass.
*HENBEST, LLOYD G., U. S. Geological Survey, Washington, D. C.
HIBBARD, CLAUDE W., Kansas University, Museum of Vertebrate Paleontology, Lawrence, Kan.
HIBBARD, RAYMOND R., 219 Bissell Ave., Buffalo, N. Y.
HINCHEY, NORMAN SHREVE, Box 476, Centralia, Ill.
*HOFFMEISTER, J. E., Dept. of Geology, University of Rochester, Rochester, N. Y.
HOLLINGSWORTH, RICHARD VINCEN, Exploration Dept., Shell Oil Co., Midland, Tex.
HOLZWASSER, FLORRIE, 3001 Broadway, New York, N. Y.
HOPF, ROBERT W., Shell Oil Co,, 641 M. & M. Bldg., Houston, Tex.
HOSICK, MRS. E. O., 1115 N. Brand Blvd., Glendale, Calif.
HOSKINS, JOHN HOBART, Dept. of Botany University of Cincinnati, Cincinnati, Ohio.
*HOWE, H. V., Louisiana State Univ., Baton Rouge, La.
*HOWELL, B. F., Dept. of Geology, Princeton University, Princeton, N. J.
*HUBBARD, BELA, 30 Rockefeller Plaza, New York, N. Y.
HUDDLE, J. W., Box 416, Chapel Hill, N. C.
HUFFMAN, GEORGE GARRETT, 509 West 121st St., New York, N. Y.
HUMPHREY, WILLIAM E., The Texas Petr. Co., 1408 Alamo Natl. Bldg., San Antonio, Tex.
*HUSSAKOF, LOUIS, American Museum of Natural History, New York, N. Y.
HUSSEY, RUSSELL C., 595 Riverview Drive, Rt. 2, Ann Arbor, Mich.
HUTCHINS, FORBES MEREDITH, 3524 Ontario Ave., Montreal, P. Q., Canada.
HUTTO, MRS. MASON P., c/o Dr. C. E. Brown, 3231 Washington Blvd., Chicago, Ill.

IMLAY, RALPH W., Room 331, U. S. National Museum, Washington, D. C.
*ISRAELSKY, MERLE CATHCART, Union Producing Co., 841 M. & M. Bldg., Houston, Tex.

*JACKSON, ROBERT T., Peterborough, N. H.
JEFFORDS, RUSSELL MACGREGOR, P. O. Box 854, Morgantown, W. Va.
JENNINGS, OTTO E., Carnegie Museum, Pittsburgh, Pa.
JENNINGS, PHILIP H., Magnolia Petroleum Co., Box 872, Lake Charles, La.
*JEPSEN, GLENN L., Dept. of Geology, Princeton University, Princeton, N. J.
JEWETT, JOHN MARK, State Geological Survey, Lawrence, Kan.
*JOHNSON, J. HARLAN, Box 306, Golden, Colo.
JOHNSTON, FRANCIS NEWLANDS, 4 East Leland St., Chevy Chase, Md.

KAY, J. LEROY, Carnegie Museum, Pittsburgh, Pa.
*KAY, G. MARSHALL, Dept. of Geology, Columbia University, New York, N. Y.
KEEN, A. MYRA, Box 1563, Stanford University, Calif.
KEENAN, JAMES, Magnolia Petroleum Co., Box 535, Mt. Vernon, Ill.
*KELLOGG, REMINGTON, U. S. National Museum, Washington, D. C.
*KELLUM, LEWIS B., Museum of Paleontology, University of Michigan, Ann Arbor, Mich.
KELLY, WILLIAM A., Michigan State College, East Lansing, Mich.
KEW, W. S. W., 1215 North Howard St., Glendale, Calif.
KINDLE, CECIL H., The College of the City of New York, 139th St. & Convent Ave., New York, N. Y.
*KING, ROBERT E., 613 N. Lake St., Carlsbad, N. M.
*KIRK, EDWIN, U. S. National Museum, Washington, D. C.
*KLEINPELL, ROBERT MINSSEN, 675 Euclid Ave., Pasadena, Calif.
*KNIGHT, JAMES BROOKES, Dept. of Geology, Princeton University, Princeton, N. J.
*KNIGHT, S. H., University of Wyoming, Laramie, Wyo.
KNOX, ARTHUR STEWART, 65 Bromfield Road, West Somerville, Mass.
KOERNER, HAROLD E., Dept. of Geology, Lafayette College, Easton, Pa.

KŘÍŽ, STANISLAV, 315 Dept. of Geology, Princeton University, Princeton, N. J.
KUMMEL, BERNHARD, Dept. of Geology, State University of Iowa, Iowa City, Iowa.

*LADD, HARRY S., U. S. National Museum, Washington, D. C.
LAIRD, WILSON M., Dept. of Geology, University of North Dakota, Grand Forks, N. D.
LALICKER, CECIL GORDON, Dept. of Geology, University of Oklahoma, Norman, Okla.
LAMBORN, MRS. HELEN MORNINGSTAR, 224 Piedmont Road, Columbus, Ohio.
LAMOTTE, ROBERT S., 667 Aileen St., Oakland, Calif.
LANDES, ROBERT W., International Petroleum Co., Casilla 206, Guayaquil, Ecuador, S.A.
*LAUDON, LOWELL R., University of Kansas, Lawrence, Kan.
*LAVERDIÈRE, JOSEPH W., Faculté des Sciences, Boulevard de l'Entente, Quebec, Canada.
LEITH, EDWARD I., Dept. of Geology, Univ. of Manitoba, Winnipeg, Man., Canada.
LIMPER, KARL ESSLINGER, c/o J. W. Blyth, College Hill, Clinton, N. Y.
*LOCHMAN, CHRISTINA, Dept of Geology, Mount Holyoke College, South Hadley, Mass.
LOEBLICH, ALFRED RICHARD, JR., Dept. of Geology, The Tulane Univ. of La., New Orleans, La.
LOEBLICH, HELEN TAPPAN, Dept. of Geology, The Tulane Univ. of La., New Orleans, La.
LOWENSTAM, HEINZ A., Illinois State Museum, Springfield, Ill.
LOZO, FRANK EDGAR, JR., Dept. of Geology, Texas Christian University, Fort Worth, Tex.
*LULL, RICHARDS S., Peabody Museum, Yale University, New Haven, Conn.
LUPHER, RALPH L., Dept. of Geology, State College of Washington, Pullman, Wash.

MACALPIN, ARCHIE J., West Texas State College, Canyon, Tex.
MACGINTHIE, HARRY, Box 1184, Arcata, Calif.
MACKAY, DONALD K., 1409 Ingraham St., N. W., Washington, D. C.
MACNEIL, F. STEARNS, U. S. National Museum, Washington, D. C.
MARSHALL, PAULINE, 111–56, 76 Drive, Forest Hills, New York, N. Y.
MARTIN, LOIS T., 2218 "D" St., Bakersfield, Calif.
*MATHER, K. F., Harvard Geological Museum, Cambridge, Mass.
MAXSON, JOHN HAVILAND, Dept. of Geology, California Institute of Technology, Pasadena, Calif.
MCEWAN, EULA D., 1223 H St., Lincoln, Neb.
*MCFARLAN, ARTHUR C., 1712 Fairway Drive, Lexington, Ky.
MCGLAMERY, WINIFRED, State Geological Survey, University, Ala.
MCGREGOR, J. H., Dept. of Zoology, Columbia University, New York, N. Y.
*MCKEE, EDWIN DINWIDDIE, Dept. of Geology, Univ. of Arizona, Tucson, Ariz.
MCNAIR, ANDREW HAMILTON, Box 823, Hanover, N. H.
MEFFERD, RALPH LEROY, Ainsworth, Neb.
MELLEN, F. F., Leavell Woods, Jackson, Miss.
MENCHER, ELY, Instituto de Geologia, Avenida San Martin 369, Caracas, Venezuela, S.A.
*MERRIAM, CHARLES W., Laboratory of Paleontology, Cornell University, Ithaca, N. Y.
*MERRIAM, JOHN C., Dept. Geological Sciences, Calif. Institute of Technology, Pasadena, Calif.
MESLER, RECTOR D., U. S. Geological Survey, Washington, D. C.
MESSINA, ANGELINA ROSE, American Museum of Natural History, New York, N. Y.
*MEYERHOFF, HOWARD A., Dept. of Geology, Smith College, Northampton, Mass.
*MILLER, ARTHUR K., Dept. of Geology, State University of Iowa, Iowa City, Iowa.
MILLER, RALPH LEROY, Box 793, Marion, Va.
MOORE, CARL A., Box 1151, Seminole, Okla.
MOORE, PRENTISS D., Box 753, Midland, Tex.
*MOORE, RAYMOND C., University of Kansas, Lawrence, Kan.
MORAN, ROBERT B., 437 S. Hill St., Los Angeles, Calif.
MOREMAN, W. L., Magnolia Petroleum Co., Box 971, Oklahoma City, Okla.
*MORSE, WILLIAM C., University of Mississippi, University, Miss.
*MULLER, SIEMON W., Dept. of Geology, Stanford University, Calif.

NADEAU, MRS. E. H., 1018 Bomparte Ave., Webster Groves (St. Louis Co.), Mo.
*NEEDHAM, CLAUDE E., Dept. of Geology, New Mexico School of Mines, Socorro, N. M.
NEELY, JOSEPH, Lovell, Wyo.
NELSON, ELMER R., JR., Public Museum, Milwaukee, Wis.
*NEWELL, NORMAN D., Dept. of Geology, Univ. of Wisconsin, Madison, Wis.
NOMLAND, JORGEN O., Tunnel Road, Lafayette, Calif.
NORTHROP, STUART A., University of New Mexico, Albuquerque, N. M.

*OKULITCH, VLADIMIR J., Dept. of Geology, Univ. of Toronto, Toronto 5, Ont., Canada.
*OLSSON, AXEL A., 48 Woodside Ave., Gloversville, N. Y.

*PACK, R. W., P. O. Box 2831, Beaumont, Tex.
*PACKARD, EARL L., 13 Edgewood Way, Corvallis, Ore.
PAGUAGA, ALFONSO SEGURA, National Museum, San José, Costa Rica.
PALMER, MRS. D. K., Neptuno 1860, Havana, Cuba.
*PALMER, MRS. KATHERINE VAN WINKLE, 206 Oakhill Road, Ithaca, N. Y.
PEABODY, FRANK E., Dept. of Paleontology, Univ. of California, Berkeley, Calif.
*PECK, LT. RAYMOND E., 501 W. Agarita, San Antonio, Texas.
PECK, W. H., Box 212, Ekalaka, Mont.
*PETRUNKEVITCH, ALEXANDER, Osborn Zool. Laboratory, Yale Station, New Haven, Conn.
PHLEGER, FRED B., JR., Dept. of Geology, Amherst College, Amherst, Mass.
PLOGER, LOUIS WILLIAM, 254 Roosevelt Ave., Syracuse, N. Y.
*PLUMMER, FREDERICK B., Bureau of Economic Geology, University of Texas, Austin, Tex.
*PLUMMER, MRS. HELEN, 3109 Walling Drive, Austin, Tex.
*POHL, ERWIN R., Horse Cave, Ky.
POPENOE, WILLIS PARKISON, Box 548, Daingerfield, Tex.
POTTER, FRANKLIN CARL, Ohio University, Athens, Ohio.
PROUTY, CHILTON EATON, 12 Maplehurst Park, Knoxville, Tenn.

QUIGLEY, PVT. CLAUDE MERLE, JR., 30th Engineers, Co. B, Ft. Belvoir, Va.

RADABAUGH, ROBERT E., Staff House, Gilman, Colo.
RAINWATER, MRS. E. H., 3021 Cason Street, Houston, Tex.
*RATHBURN, MARY JANE, U. S. National Museum, Washington, D. C.
*RAYMOND, PERCY E., Museum of Comparative Zoology, Cambridge, Mass.
READ, WILLIAM F., Lawrence College, Appleton, Wis.
*REEDS, CHESTER A., P. O. Box 142, Ghent, N. Y.
*REESIDE, JOHN B., JR.,P. O. Box 177, Hyattsville, Md.
REIMANN, IRVING G., Buffalo Museum of Science, Buffalo, N. Y.
REINHART, PHILIP WINGATE, Geol. Dept., Shell Oil Co., 1008 W. 6th St., Los Angeles, Calif.
RENFRO, MILLICENT, 2901 Bomar Avenue, Ft. Worth, Texas.
*RESSER, CHARLES E., U. S. National Museum, Washington, D. C.
RICHARDS, EDWARD F., Dept. of Geology, University of Alabama, University, Ala.
RICHARDS, HORACE GARDINER, 509 Woodland Terrace, Philadelphia, Pa.
RICHEY, KING A., Box 751, National Park Service, Carlsbad, N. M.
RIGNEY, CHAPLAIN HAROLD WILLIAM, Army Air Force, Africa Middle East Wing, A.P.O. 625, c/o Postmaster, Miami, Fla.
*ROBERTS, JOSEPH K., University of Virginia, Charlottesville, Va.
ROBINSON, WILBUR I., Texas Technological College, Lubbock, Tex.
*ROMER, A. S., Museum of Comparative Zoology, Cambridge, Mass.
ROOT, TOWNER B., P. O. Box. 218, Hamilton, N. Y.
ROSSELLO, PIERINA, Dept. of Paleontology, Univ. of California, Berkeley, Calif.
ROTHWELL, W. THOMAS, JR., Richfield Paleontology Lab., P. O. Box 470, Long Beach, Calif.

*RUEDEMANN, RUDOLF, New York State Museum, Albany, N. Y.
*RUSSELL, LORIS S., Royal Ontario Museum of Palaeontology, Toronto 5, Ont., Canada.
RUTH, JOHN W., 1716 Baldwin Ave., Arcadia, Calif.
RYNIKER, CHARLES, Gypsy Oil Company, P. O. Box 661, Tulsa, Okla.

SALMON, ELEANOR SEELY, 521 West 112th St., New York, N. Y.
SANDER, NESTOE, c/o CASOC, Bahrein Island, Persian Gulf.
*SANDIDGE, JOHN R., Magnolia Petroleum Co., 1704 Alamo Natl. Bldg., San Antonio, Tex.
SANFORD, JOHN THERON, Magnolia Petroleum Co., Box 1828, Oklahoma City, Okla.
*SCHENCK, HUBERT G., Dept. of Geology, Stanford University, Calif.
SCHENK, EDWARD THEODORE, 537 Avenue I, Boulder City, Nev.
SCHEVILL, WILLIAM E., Museum of Comparative Zoology, Cambridge, Mass.
*SCHLAIKJER, ERICH M., Brooklyn College, Bedford Avenue & Avenue H., Brooklyn, N. Y.
SCHOONOVER, LOIS M., U. S. Geological Survey, Washington, D. C.
SCHOPF, JAMES MORTON, Natural Resources Bldg., Illinois State Geol. Survey, Urbana, Ill.
*SCOTT, GAYLE, Dept. of Geology, Texas Christian University, Fort Worth, Tex.
*SCOTT, HAROLD WILLIAM, 246 Nat. History Bldg., University of Illinois, Urbana, Ill.
*SCOTT, WILLIAM BERRYMAN, Princeton, N. J.
SECRIST, MARK H., Dept. of Geology, Johns Hopkins University, Baltimore, Md.
*SELLARDS, ELIAS H., University of Texas, Austin, Tex.
SHIDELER, WILLIAM H., Miami University, Oxford, Ohio.
*SHIMER, HERVEY W., Massachusetts Institute of Technology, Cambridge, Mass.
*SHROCK, ROBERT R., Dept. of Geology, Massachusetts Inst. of Technology, Cambridge, Mass.
*SIMPSON, GEORGE G., American Museum of Natural History, New York, N. Y.
SINCLAIR, GEORGE WINSTON, Sir George Williams College, Montreal, P.Q., Canada.
*SKINNER, MORRIS F., Frick Laboratories, American Museum of Natural History, New York, N. Y.
SLOSS, LAURENCE L., Montana School of Mines, Butte, Mont.
*SMITH, BURNETT, West Lake St., Skaneateles, N. Y.
*SMITH, EDWARD S. C., Dept. of Geology, Union College, Schenectady, N. Y.
SMITH, ERNEST RICE, Dept. of Geology, DePauw University, Greencastle, Ind.
SMITH, HOMER JAMES, Dept. of Geology, University of Tulsa, Tulsa, Okla.
*SMITH, STANLEY, The University, Bristol, England.
SOUTHWORTH, CHARLES H., Box 151, Thedford, Ontario, Canada.
*SPIEKER, EDMUND M., Ohio State University, Columbus, Ohio.
SPIVEY, ROBERT CHARLES, Shell Oil Co., Inc., Midland, Tex.
STAINBROOK, MERRILL A., Texas Technological College, Lubbock, Tex.
*STANTON, T. W., U. S. National Museum, Washington, D. C.
*STAUFFER, CLINTON R., University of Minnesota, Minneapolis, Minn.
*STEPHENSON, L. W., U. S. Geological Survey, Washington, D. C.
STEPHENSON, MORTON B., Stanolind Oil & Gas Co., Box 3092, Houston, Tex.
STERNBERG, CHARLES WILLIAM, Ohio Oil Co., Marshall, Ill.
STERNBERG, RAYMOND M., Royal Ontario Museum of Palaeontology, Toronto 5, Ont., Canada.
*STETSON, HENRY C., Museum of Comparative Zoology, Cambridge, Mass.
*STEWART, GRACE A., Dept. of Geology, Ohio State University, Columbus, Ohio.
STEWART, RALPH B., 405 U. S. National Museum, Washington, D. C.
STIRTON, R. A., Dept. of Paleontology, University of California, Berkeley, Calif.
*STOCK, CHESTER, California Institute of Technology, Pasadena, Calif.
*STOCKDALE, PARIS B., University of Tennessee, Knoxville, Tenn.
STONER, REGINALD C., Standard Oil Building, San Francisco, Calif.
STOUT, THOMPSON MYLAN, Dept. of Geology, University of Nebraska, Lincoln, Neb.
STOVALL, JOHN WILLIS, University of Oklahoma, Norman, Okla.

*STOYANOW, ALEXANDER, University of Arizona, Tucson, Ariz.
STUBBS, SIDNEY ALTON, P. O. Box 132, Bradenton, Fla.
STUMM, ERWIN CHARLES, Dept. of Geology, Oberlin College, Oberlin, Ohio.
STURGEON, MYRON THOMAS, Michigan State Normal School, Ypsilanti, Mich.
SUMMERSON, CHARLES H., Dept. of Geology, University of Illinois, Urbana, Ill.
*SUTTON, A. H., Aluminum Ore Company, Rosiclare, Ill.
SWANN, DAVID HENRY, Brown University, Providence, R. I.
*SWARTZ, CHARLES K., Johns Hopkins University, Baltimore, Md.
*SWARTZ, FRANK M., Pennsylvania State College, State College, Pa.

*TALBOT, MIGNON, Mount Holyoke College, South Hadley, Mass.
TAYLOR, EDWARD HARRISON, 113 Snow Hall, University of Kansas, Lawrence, Kan.
*TEICHERT, CURT, University of Western Australia, Crawley, Western Australia.
THALMANN, HANS E., P. O. Box 803, Guayaquil, Ecuador, S. A.
THOMAS, HORACE D., University of Wyoming, Laramie, Wyo.
*THOMAS, NORMAN, LOUIS, P. O. Box 38, Bakersfield, Calif.
*THOMPSON, MARCUS LUTHER, State Geol. Surv. of Kansas, Univ. of Kansas, Lawrence Kan.
TIEJE, ARTHUR J., Cordova Hotel, Los Angeles, Calif.
TOEPELMANN, WALTER C., University of Colorado, Boulder, Colo.
*TOLMANCHOFF, I. P., Carnegie Museum, Pittsburgh, Pa.
TOULMIN, LYMAN D., JR., Geological Survey of Alabama, University, Ala.
TROMP, S. W., Socony Vacuum Oil Co., Sharia Ibrahim Pasha, Cairo, Egypt.
*TURNER, F. E., Texas Agricultural and Mechanical College, College Station, Tex.
*TWENHOFEL, WILLIAM H., University of Wisconsin, Madison, Wis.

*ULRICH, EDWARD O., U. S. National Museum, Washington, D. C.
UNKLESBAY, ATHEL G., U. S. Geol. Survey, P. O. Drawer 631, Tallahassee, Fla.

VAN HOUTEN FRANKLYN B., Eastern Sea Frontier, 90 Church St., New York, N. Y.
*VAN TUYL, FRANCIS M., Colorado School of Mines, Golden, Colo.
*VAUGHAN, T. WAYLAND, 3333 P St., N.W., Washington, D. C.
VESTAL, FRANKLIN E., Dept. of Geology, Rosenwald Hall, University of Chicago, Chicago, Ill
*VOKES, HAROLD E., American Museum of Natural History, New York, N. Y.

WAAGÉ, KARL M., Dept. of Geology, Princeton University, Princeton, N. J.
WALDRAM, ENSIGN ROBERT J., 332 Stafford St., Washington, Mo.
WALKER, MYRL VINCENT, Glacier National Park, Box 406, Belton, Mont.
*WANLESS, HAROLD R., 241 Natural History Bldg., University of Illinois, Urbana, Ill.
WARD, FRANK HAWLEY, P. O. Box 24, Beechwood Station, Rochester, N. Y.
*WARREN, PERCIVAL S., University of Alberta, Edmonton, Alta., Canada.
*WARTHIN, ALDRED SCOTT, JR., Vassar College, Poughkeepsie, N. Y.
*WELLER, J. MARVIN, State Geological Survey of Illinois, Urbana, Ill.
WELLES, SAMUEL PAUL, Museum of Paleontology, University of California, Berkeley, Calif.
WELLS, DANA, Dept. of Geology, W. Va. Univ., Mineral Industries Bldg., Morgantown, W. Va.
*WELLS, JOHN WEST, Dept. of Geology, Ohio State University, Columbus, Ohio.
WERNER, COURTNEY, Dept. of Geology, Washington University, St. Louis, Mo.
*WETMORE, ALEXANDER, U. S. National Museum, Washington, D. C.
WHEELER, HARRY EUGENE, Mackay School of Mines, University of Nevada, Reno, Nev.
*WHITCOMB, LAWRENCE, Dept. of Geology, Lehigh University, Bethlehem, Pa.
WHITE, THEODORE E., Museum of Comparative Zoology, Cambridge, Mass.

WHITMORE, FRANK C., JR., P. O. Box 191, Kingston, R. I.
*WHITNEY, F. L., University of Texas, Austin, Tex.
*WICKENDEN, ROBERT THOMAS DAUBIGNY, Geological Survey of Canada, Ottawa, Canada.
WILDER, BEVERLY B., Dept. of Paleontology, Univ. of California, Berkeley, Calif.
*WILLARD, BRADFORD, Dept. of Geology, Lehigh University, Bethlehem, Pa.
*WILLIAMS, JAMES STEELE, U. S. Geological Survey, Washington, D. C.
WILLIAMS, JAMES STEWART, Dept. of Geology, Utah Agricultural College, Logan, Utah.
*WILLIAMS, MERTON Y., University of British Columbia, Vancouver, B. C., Canada.
*WILSON, C. W., JR., Dept. of Geology, Vanderbilt University, Nashville, Tenn.
WILSON, LESLIE E., 215 7th Ave., San Mateo, Calif.
*WILSON, ROBERT WARREN, Dept. of Geology, University of Colorado, Boulder, Colo.
WINKLER, VIRGIL DEAN, Standard Oil Co. of Venezuela, Caripito, Venezuela, S. A.
WINTON, W. M., Texas Christian University, Fort Worth, Tex.
*WOOD, MAJ. ALBERT ELMER, 45 F. A. Bn., A.P.O. 8, Ft. Leonard Wood, Mo.
*WOOD, HORACE E., II, Dept. of Biology, University of Newark, Rector St., Newark, N. J.
*WOODRING, WENDELL, P., U. S. Geological Survey, Washington, D. C.

YOUNG, FREDERICK PENTZ, JR., 430 West 118th St., New York, N. Y.
YOUNG, JOHN A., JR., Dept. of Geology, Michigan State College, East Lansing, Mich.

CORRESPONDENTS DECEASED

BATHER, DR. F. A. Died Mar. 20, 1934.
BOULE, MARCELLIN. Died July 19, 1942.
BUCKMAN, S. S. Died Feb. 26, 1929.
CANU, FERDINAND. Died Feb. 12, 1932.
COBBOLD, EDGAR STERLING. Died Nov. 20, 1936.
DEPÉRET, PROF. CHARLES. Died May 17, 1939.
KAIER, PROF. JOHAN. Died Oct. 31, 1931.
KOKEN, E. Died Nov. 24, 1912.
KOLIHA, DR. JAN. Died April 7, 1939.
NATHORST, DR. A. C. Died Jan. 20, 1921.
POMPECKI, DR. J. F. Died July 8, 1930.
STEFANINI, PROF. G. Died Sept. 15, 1938.
WOODWARD, DR. H. Died Sept. 6, 1921.

MEMBERS AND FELLOWS DECEASED

*ALDRICH, TRUMAN H. Died Apr. 28, 1932.
*AMI, HENRY, M. Died Jan. 4, 1931.
ARMSTRONG, EDWIN J. Died Jan. 21, 1929.
*BALL, OSCAR M. Died Nov. 11, 1942.
*BARRELL, JOSEPH. Died May 4, 1919.
BARROWS, ALBERT L. Died Nov. 7, 1942.
*BEEDE, JOSHUA W. Died Feb. 27, 1940.
*BELANSKI, CHARLES H. Died Apr. 30, 1929.
*BENSLEY, B. A. Died Jan. 20, 1934.
*BILLINGS, W. R. Died Mar. 1, 1920.
*BOSTWICH, THOMAS A. Died Apr. 1923.
*BROWN, T. C. Died Feb. 28, 1934.
*CALVIN, SAMUEL. Died Apr. 17, 1911.
*CLARK, WM. B. Died July 27, 1917.
*CLARKE, JOHN M. Died May 29, 1925.
*CLELAND, HERDMAN F. Died Jan. 24, 1935.
*CROOK, A. R. Died May 30, 1930.
CROZEL, GEORGE. Died Oct. 1921.
DALL, W. H. Died Mar. 27, 1927.
*DEAN, BASHFORD. Died Dec. 6, 1928.
*DERBY, ORVILLE A. Died Nov. 27, 1915.
DOUGLASS, EARL. Died Jan. 13, 1931.
*EASTMAN, CHAS. R. Died Sept. 27, 1918.
*FOERSTE, AUGUST F. Died Apr. 23, 1936.
*FONTAINE, WM. M. Died Apr. 30, 1913.
GIBB, HUGH. Died Feb. 28, 1932.
*GIDLEY, JAMES WM. Died Sept. 26, 1931.
GILL, THEODORE N. Died Sept. 25, 1914.
GIRTY, GEORGE HERBERT. Died Jan. 27, 1939.
GORDON, ROBERT H. Died May 10, 1910.
GRAHAM, ROY. Died Aug. 9, 1939.
*GRANGER, WALTER. Died Sept. 7, 1941.
HAMLIN, HOMER. Died July, 1920.
HARPER, GEORGE W. Died Aug. 19, 1918.
HAWVER, J. C. Died May 15, 1914.
*HAY, O. P. Died Nov. 2, 1930.
*HENDERSON, JUNIUS. Died Nov. 4, 1937.
HOLLAND, WM. J. Died Dec. 15, 1932.
HOLLICK, ARTHUR. Died Mar. 16, 1933.
HOLMES, WALTER W. Died Nov. 13, 1938.
*HUDSON, GEORGE H. Died Mar. 19, 1934.
*HYDE, JESSE E. Died July 3, 1936.
JOHNSTON, C. STUART. Died July 23, 1939.
*KEYTE, I. A. Died May 29, 1931.
*KINDLE, EDWARD M. Died Aug. 29, 1940.
*KNOWLTON, FRANK H. Died Nov. 21, 1926.
*LAMBE, L. M. Died Mar. 12, 1919.
LEE, WILLIS T. Died June 17, 1926.
*LOOMIS, FREDERICK B. Died July 28, 1937.
LUSK, RALPH G. Died July 27, 1927.
LUTHER, D. D. Died Dec. 17, 1923.
LYON, VICTOR W. Died Aug. 17, 1919.
MACBRIDE, THOMAS H. Died Mar. 27, 1934.
*MANSFIELD, WENDELL C. Died July 24, 1939.
MARTIN, BRUCE. Died Dec. 23, 1919.
MARTIN, HANDELL T. Died Jan. 15, 1931.

MATTHEW, GEO. F. Died Apr. 17, 1923.
*MATTHEW, W. D. Died Sept. 24, 1930.
MEACHEM, R. P. Died Feb. 13, 1934.
MOODY, W. L. Died Oct. 9, 1930.
NOBLE, G. KINGSLEY. Died Dec. 9, 1940.
*NOE, ADOLF C. Died Apr. 10, 1939.
*PARKS, WM. A. Died Oct. 3, 1936.
PATTEN, WM. Died Oct. 23, 1932.
.PENHALLOW, DAVID P. Died Oct. 20, 1910.
PETERSON, O. A. Died Nov. 13, 1933.
*PROSSER, C. S. Died Sept. 11, 1916.
*RATHBUN, MARY JANE. Died Apr. 4, 1943.
ROUNDY, PAUL V. Died June 21, 1937.
*SCHUCHERT, CHARLES. Died Nov. 20, 1942.
*SEELY, HENRY M. Died May 4, 1917.
*SINCLAIR, W. J. Died Mar. 25, 1935.
SLOCUM, ARTHUR W. Died Nov. 20, 1937.
*SPRINGER, FRANK. Died Sept. 22, 1927.
TEGLAND, NELLIE M. Died Dec. 1930.
TELLER, EDGAR E. Died July 19, 1923.
*THOMAS, A. O. Died Jan. 13, 1931.
*TILTON, J. L. Died Nov. 17, 1930.
*TWITCHELL, G. B. Died Apr. 28, 1933.
*TWITCHELL, M. W. Died Apr. 8, 1927.
*VAN INGEN, GILBERT. Died July 7, 1925.
*VODGES, ANTHONY W. Died Feb. 8, 1923.
*WALCOTT, CHARLES D. Died Feb. 9, 1927.
*WARING, CHARLES A. Died Nov. 5, 1918.
WARNER, WILLIAM C. Died Sept. 29, 1941.
*WEINZIERL, MRS. J. F. Died Sept. 28, 1928.
*WELLER, STUART. Died Aug. 5, 1927.
*WHITE, DAVID. Died Feb. 7, 1935.
WHITFIELD, H. P. Died Apr. 6, 1910.
*WILLIAMS, HENRY S. Died July 31, 1918.
WILLISTON, S. W. Died Aug. 30, 1918.
WILSON, HERRICK E. Died Jan. 24, 1925.
WHITTAKER, EDW. Died Sept. 14, 1924.

NOMINATIONS FOR OFFICES IN THE PALEONTOLOGICAL SOCIETY FOR 1944

In accordance with the provisions of Chapter IV, Section 1, of the By-Laws, the Council of the Paleontological Society announces the following nominations for offices in the Society for 1944:

For President, B. F. HOWELL, Princeton, N. J.
For Vice-President, SIEMON W. MULLER, Stanford University, Calif.
For Secretary, H. E. VOKES, New York, N. Y.
For Treasurer, ROBERT R. SHROCK, Cambridge, Mass.
For Editor, C. WYTHE COOKE, Washington, D. C.

GENERAL COUNCIL ON ZOOLOGICAL NOMENCLATURE

The undersigned zoologists, resident in the United States of America, at the invitation of the Committee on Nomenclature of the American Society of Mammalogists and with the cooperation of the "American Commission on Scientific Nomenclature" of the Entomological Society of America, do hereby associate themselves together as a society and certify as follows:

First: The name of the society shall be the General Council on Zoological Nomenclature.

Second: The objects of the Society shall be:

(A) To act in an advisory capacity in all matters concerning zoological nomenclature during the World War and for such time thereafter as it may consider desirable.

(B) To administer, amend, interpret, and maintain a code of nomenclature for the use of zoologists.

(C) To cooperate with societies maintaining committees on nomenclature, at least those represented in its own membership.

(D) To retain within itself important powers of decision and legislation and of substitutions and additions to its membership, but always subject to full hearings and the advice and counsel of one or more of the committees above mentioned.

(E) To cooperate with zoologists practiced in nomenclature who are residents of foreign countries when the war is ended or as soon thereafter as may be practicable.

G. F. Ferris	Remington Kellogg
Wilfred H. Osgood	H. A. Pilsbry
James A. G. Rehn	Karl P. Schmidt
George G. Simpson	A. Wetmore
John T. Zimmer	

Merely on the face of it, the above may seem to be a self-constituted body of dubious possibilities and audacious construction. That this is not the case may be evident when its history and purposes are explained. It is the outgrowth of numerous informal discussions among a large number of zoologists during the past few years and of formal action taken by at least two national societies.

The International Commission on Zoological Nomenclature, after hostilities began in Europe in 1939, became practically nonfunctional. This created a situation in which all cooperative action was endangered and nearly a century's hard-earned progress in nomenclature was threatened. Individuals and organizations began to discuss special codes for their separate groups only and in some cases took definite action. Recently a German (Poche) has promulgated a code of his own and in general at the moment every zoologist having a nomenclatural problem finds himself without appeal to any constituted authority. It was precisely to avoid this condition that codes and commissions were devised.

Discussion among zoologists unanimously recognized the emergency, but it was difficult to arrive at a basis for action which did not involve very great delay and long-drawn controversy. There were those who felt that the international idea could not be abandoned and others who advocated complete divorce from the Old World. The latter pointed to the success of the International Commission as being mainly due to the American C. W. Stiles, whose final conclusion (see *Science*, vol. 73, pp. 349–354, 1931) was that it was not further workable. Among those holding this opinion were several Europeans.

As announced in *Science* (June 12, 1942) the Entomological Society of America, pursuant to action taken at its meeting in December, 1941, formed an "American Commission on Scientific Nomenclature in Entomology" apparently with the object of proceeding independently. Somewhat later at its annual meeting in April 1942 the American Society of Mammalogists instructed its standing committee on nomenclature "to act pro-tem in the present world crisis for the Committee (*sic*) on Nomenclature of the International Commission." The Mammalogists' committee felt that any committee restricted to a particular branch of zoology would be ineffective. Therefore, with the approval of the Society's president and principal directors, this committee entered into correspondence with the entomologists proposing that the two committees, without further authorization, jointly sponsor the selection of a small group of representative nomenclaturists to "take over," at least for the time being. Full cooperation between the two committees proved impractical without great loss of time, so the Mammalogists' committee, after receiving encouragement from the majority of the entomologists, selected and organized the group as indicated above. The membership of the Mammalogists' committee which carried this out was as follows: A. Cabrera, E. R. Hall, G. S. Miller, Jr., W. H. Osgood, T. S. Palmer, G. G. Simpson, and G. H. Tate.

The "Council" thus formed is frankly experimental and the method of its genesis is unusual, but those responsible for it have felt that any other method, especially in these times when large general meetings are interdicted, would defeat itself in prolonged discussion and fatal delay. Under restrictions which the Council has placed upon itself it is hoped that it may be a wholly representative and cooperative body. A brief set of by-laws has been adopted in which important provisions are to the effect (1) that the active membership shall not exceed fifteen, (2) that additions and replacements shall be made only from candidates nominated by large associations of zoologists, and (3) that no important action can be taken without first obtaining the opinion of at least two nomenclatural committees of national societies and several individuals not members of the Council. A judicial function is thus implied preceding any legislation.

It does not propose to supersede any existing special nomenclatural committees, but on the contrary it is designed to stimulate them to greater interest and more action. Its postwar status is problematical, but at least as a temporary measure and an effort in a direction urgently needing attention, it is hoped it may find support. At an early date it is proposed to increase the membership from nine to eleven in order to cover important branches of zoology which are not now well represented.

The by-laws giving details of proposed action will soon be available for distribution to any interested zoologists who may apply for them.

WILFRED H. OSGOOD, *Secretary*
Field Museum of Natural History,
Chicago, Ill.

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